

**TRUE DEFINITION OF COSMIC RED SHIFT AND A REVIEW
ON COSMIC EXPANSION BASED ON MICROSCOPIC PHYSICAL
CONSTANTS AND TRUE RED SHIFT**

U. V. S. Seshavatharam

Honorary faculty, I-SERVE, Survey no-42, Hitech City
Hyderabad-84, Telangana, India
seshavatharam.uvs@gmail.com

S. Lakshminarayana

Department of Nuclear Physics, Andhra University
Visakhapatnam-03, AP, India
lnsrirama@gmail.com

Received April 29, 2023

Revised May 16, 2023

Abstract

Considering our recently proposed light speed expanding Hubble-Hawking Universe and considering the recent paper pertaining to cosmic halt authored by Cosmin Andrei, Anna Iijas, and Paul J. Steinhardt and reviewed by Saul Perlmutter, in this paper we propose a very simple model of universe having early stage light speed expansion and current stage quantum halt accompanied by light speed rotation. Representing early cosmic expansion and rotation as an outward spiral, Hubble's law can be considered as a representation of current cosmic rotation having no further expansion. Proceeding further, we would like to emphasize the point that, traditional definition of cosmic red shift is absolutely wrong. Based on photon energy, true cosmic red shift must be defined as the ratio of change in wavelength to the observed wavelength of photon. Halting state of the current universe can be understood with a combined study of the gravitational potential energy of proton and electron separated by a distance of 0.84 fermi and half the product of reduced Planck's constant and current Hubble parameter.

Keywords: Planck ball; Quantum cosmology; Hubble-Hawking universe; Light speed expansion; Light speed rotation; Cosmic halt with quantum physics;

1. Introduction

It is very surprising to note that, after 20 years of a strong footing, based on 'quintessence' driven universe, within coming 100 million years, universe is coming to a halt and slowly getting contraction to form a big crunch [1]. This technical paper has been reviewed by one of the co-founders of the accelerating universe, Saul Perlmutter [2] and got published in the Proceedings of the National Academy of Sciences of USA in April 2022. It is certain that this paper will bring a radical change among mainstream cosmologists and engineers. As per the papers published in Astronomical Journal 2012 [3] and Nature-Scientific Reports 2016 [4], data pertaining to 580 to 740 super novae clearly reveal that, universe is expanding at an uniform rate. In 2018-2019, the same result has been obtained by a student Lisa Goh Wan Khee of National University of Singapore supervised by Cindy Ng [5]. This information can be considered as a base for current non-accelerating universe.

Mainstream cosmologists are strongly believing that, current expanding universe is having no center and no rotation [6]. Scientists who are strongly believing in cosmic rotation suggest that, current magnitude of cosmic angular velocity is very small in magnitude and is beyond the scope of observations [7,8,9]. Unfortunately, applications of cosmic angular velocity are also lagging in acquiring a strong foundation in constructing workable models of rotating cosmologies. In this context, we emphasize the following facts.

- 1) Quantum cosmology [10] point of view, in a theoretical approach, Spin or Rotation can be given a chance in developing quantum models of cosmology.
- 2) Current model of Lambda cosmology [11] is badly failing in incorporating quantum gravity concepts.
- 3) Very few cosmologists are working on quantum cosmology models.
- 4) Clearly speaking, no cosmologist is having a clear vision of quantum models of cosmology.

Keeping these points in view, we can confidently say that, models of cosmology without cosmic rotation cannot be considered as standard models

of cosmology. In support of this statement, we propose the following logical points.

- 1) Important point to be noted is that, to have rotation, universe should have a closed or positive curvature. Three most recent technical papers [12,13,14] published in three very high impact journals seem to support a closed universe. In this context, we would like to recall the views of Di Valentino, Melchiorri and Silk [12]. According their analysis and interpretation, observed enhanced lensing amplitude of cosmic microwave background radiation can be explained with a positive curvature of the universe at 99% confidence level. According to George Ellis and Julien Larena [13], the possibility that the universe might be positively curved, although it would not solve all the existing tensions at once, opens exciting theoretical possibilities for cosmology. Proceeding further, according to Will Handley [14] - In light of the inconsistency between Planck, CMB lensing and BAO data in the context of curved universes, cosmologists can no longer conclude that observations support a flat universe.
- 2) Hubble's observations [15] can also be studied with rotating and expanding models of cosmology. In a rotating frame, quantitatively Hubble's law resembles cosmic light speed rotation concept.
- 3) General theory of relativity is no way against to cosmic rotation [16]. In a non-accelerating universe, considering red shift as a measure of galactic distances and revolving speeds, references [3,4,5] can be considered as a supporting data for a rotating universe.
- 4) Without a radial in-flow of matter in all directions towards one specific point, one cannot expect a big crunch and without a big crunch, one cannot expect a big bang. Really if there was a "big bang" in the past, with reference to formation of big bang as predicted by GTR and with reference to the cosmic rate of expansion that might have taken place simultaneously in all directions at a "naturally selected rate" about the point of big bang: "point" of big bang can be considered as the characteristic reference point of cosmic expansion in all directions. Thinking in this way, either the point of big bang or baby Planck ball can be considered as a possible centre of cosmic evolution.

- 5) If observed universe is assumed to be associated with only one big bang, then 'point of big bang' can certainly be considered as the characteristic reference point of cosmic evolution in all directions.
- 6) If currently believed cosmic big bang is really a 'singularity', it seems more logical to depend on Planck scale rather than big bang. It may be noted that, in general, gravitational singularities are not clear about "Where, When and How" like essential points that are believed to be the basics of developing any workable physical model.
- 7) No model of cosmology is clear about the origin of cosmic thermal radiation. Even though big bang model is giving lot of information on cosmic thermal evolution, origin point of view, initial conditions are beyond the scope of big bang.
- 8) Both, Planck scale and big bang are being implemented simultaneously in understanding cosmic initial conditions leading to an ambiguous situation on whether to consider only big bang or only Planck scale.
- 9) Modern cosmological observations are providing strong evidences for the existence of mysterious rotational features of large cosmic filaments [17].
- 10) Current Hubble's constant can be considered as a limiting magnitude of current cosmic angular velocity. Similarly, light speed can be considered as a limiting magnitude of current cosmic rotation speed.
- 11) Current Hubble mass can be considered as a characteristic mass limit of current universe having a closed curvature.
- 12) So far, on large scale distances, physically,
 - a) No galaxy is confirmed to have super-luminal speeds.
 - b) No verification for actual galactic receding speeds.

2. Hubble-Hawking cosmology

Based on light speed expansion, modified red shift formula, scaled Hawking's black hole temperature formula, super gravity of galactic baryon matter and baby Planck ball – in our recent publications, we have clearly established a novel model of quantum cosmology [18-28]. This paper is a modified version of our recent paper [28] and the key change is that, we consider current cosmic halt and light speed rotation in place of assumed

current light speed expansion. Here we would like to appeal that, a new model of cosmology, that follows Hubble's notion of expansion and Hawking's notion of black hole structure having thermal radiation can be called as Hubble-Hawking model of cosmology. We continue this section with the need of considering light speed expansion and rotation.

2.1 Need of considering light speed expansion and rotation

Technical publications that are having very high impact on science community are raising many new ideas and doubts on dark energy and dark matter. Now it is very clear that, there is a disagreement between main stream cosmologists and other researchers. Cosmological observations are not straight forward. For the same data, different interpretations are coming into picture with a great diversity. Right now it is not at all possible to prove the exact nature of cosmic expansion whether it is accelerating or decelerating. In this very ambiguous situation, it seems interesting to take the help of 'light speed' as a tool. There is a possibility for considering light speed radial expansion as well as light speed rotation. We would like to emphasize that,

- 1) All cosmological observations and physical studies & research are being accomplished with 'light speed' only.
- 2) So far no single experiment or no single observation confirmed super luminal physical results.
- 3) It is well confirmed that, gravitons are also moving with speed of light.
- 4) In one sentence, 'without light', there is no cosmology and there is no physics.

2.2 Present cosmic critical density, volume and mass

Currently believed cosmic critical density is, $\rho_0 \cong (3H_0^2/8\pi G)$. Considering the product of currently believed cosmic critical density and Hubble volume, $V_0 \cong \left(\frac{4\pi}{3}\right)(c/H_0)^3$, it is possible to show that, $M_0 \cong (c^3/2GH_0)$. On re-arranging this mass expression, $2GM_0/c^2 \cong c/H_0 \cong R_0$. It clearly indicates something new about the current universe in terms of current cosmic black hole mass, radius and expansion speed or rotation speed. We interpret this relation as, at present, $R_0 \cong (c/H_0) \cong 2GM_0/c^2$.

2.3 Present cosmic temperature

Currently believed cosmic temperature T_0 seems to be equal to the geometric mean of Hawking temperature [29] of Planck mass,

$T_{M_{pl}} \cong \frac{\hbar c^3}{8\pi k_B G M_{pl}}$ and Hawking temperature of current cosmic Hubble mass,

$T_{M_0} \cong \frac{\hbar c^3}{8\pi k_B G M_0}$. In a simplified form, it can be expressed as,

$T_0 \cong \frac{\hbar c^3}{8\pi k_B G \sqrt{M_{pl} M_0}}$. It clearly indicates something new about the current

cosmic temperature in terms of Hawking's Black hole physics. We interpret

this relation as, with respect to Planck scale, $T_0 \cong \frac{\hbar c^3}{8\pi k_B G \sqrt{M_{pl} M_0}} \cong \frac{\hbar \sqrt{H_0 H_{pl}}}{4\pi k_B}$

where $M_0 \cong \frac{c^3}{2GH_0}$, $M_{pl} \cong \sqrt{\frac{\hbar c}{G}}$ and $H_{pl} \cong \frac{1}{2} \sqrt{\frac{c^5}{G\hbar}}$.

For an observed value of $T_0 \cong 2.72548$ K, estimated $H_0 \cong 2.167867 \times 10^{-18} \text{ sec}^{-1} \cong 66.89 \text{ km/sec/Mpc}$. We would like to emphasize the point that, based on Hawking's black hole temperature formula, geometric mean of Planck mass and the so called Hubble mass, seems to play a crucial role in estimating the observed cosmic microwave back ground temperature, (CMBR) [30]. This kind of relation is missing in Lambda cosmology and to a great extent, currently observed discrepancy or tension in estimating the Hubble parameter can be eliminated. Proceeding further currently believed Baryon acoustic bubble radius [31] can be fitted with a simple relation of the

form, $(R_{BAC})_0 \cong \sqrt{\frac{T_0}{T_{\text{Recombination}}}} * \left(\frac{c}{H_0}\right) \cong \sqrt{\frac{2.725 \text{ K}}{3000 \text{ K}}} * \left(\frac{c}{H_0}\right) \cong \frac{c}{H_0^{1/4} H_0^{3/4}} \cong 135 \text{ Mpc}$.

Considering both Planck mass and the Universe as 'point particles', cosmic temperature relation can be derived with three hypothetical conditions,

$$\frac{GM_0 M_{pl}}{r_0^2} \cong \left(\frac{c^4}{8\pi G} \right); r_0 \cong \left(\frac{2.898 \times 10^{-3}}{2\pi T_0} \right) \text{ and } M_0 \cong \left(\frac{c^3}{2GH_0} \right). \text{ Derived relation is,}$$

$$T_0 \cong \frac{hc^3}{24.891 k_B G \sqrt{M_{pl} M_0}} \text{ and the denominator coefficient 24.891 is close to}$$

$$8\pi \cong 25.13274.$$

2.4 Present galactic light travel distances

It may be noted that, by the time of defining the definition of galactic red shift, maximum red shift value was around 0.003. In this context, in terms of energy of photon, we would like to emphasize the point that, traditional definition of cosmic red shift is absolutely wrong. True cosmic red shift must be defined as - ratio of loss in energy of photon to the energy of photon at galaxy or lab. As a consequence, in terms of wavelength of photon, red shift can be defined as, the ratio of change in wavelength to the observed wavelength of photon. In a mathematical form,

$$z_{new} \cong \frac{E_{Lab} - E_{Observed}}{E_{Lab}} \cong \frac{\lambda_{Observed} - \lambda_{Lab}}{\lambda_{Observed}} \cong 1 - \frac{\lambda_{Lab}}{\lambda_{Observed}} \cong \frac{z}{z+1}. \text{ With reference to}$$

current definition, $0 > z < \text{Infinity}$. By following our new definition, $0 > z_{new} < 1$.

It may be noted that, with our given definition, it is very easy to implement 'light speed rotation' in cosmic evolution scheme. Fig. 1 compares galactic light travel distances according to our new definition, $d_G \cong (z_{new})(c/H_0)$ (Red curve) and the conventional formula connected with dark energy density and other density fractions (Green curve). For verification, readers are encouraged to visit the URLs, <http://www.atlasoftheuniverse.com/cosmodis.c> and <https://cosmocalc.icrar.org/>. Richard Powell has written an online C program (<http://www.atlasoftheuniverse.com/cosmodis.c>) (version 1.1) for estimating the light travel distance [32]. See Appendix A for the C++ program. Using that program and considering a redshift of $z = (0.1 \text{ to } 200)$, we have prepared Figure 1. Green curve indicates the light travel distance in Lambda cosmology prepared with Omega matter = 0.32, Omega lambda = 0.68, Omega radiation = 0.0 and $H_0 = 66.87 \text{ km/sec/Mpc}$. Figure 1 will certainly encourage any cosmologist to solve Einstein's field equations with a closed curvature spreading at speed of light and rotating at speed of light. As traditional redshift is increasing from 0, error in estimated light travel distance is increasing to

+8.59% at $z \approx 1.20$ and from there onwards, error is reaching to 0% at $z \approx 11.5$ to 11.55. Proceeding further, error is reaching to -5.14% at $z \approx 200.0$. By considering $z_{rev}c$ as the revolving speed of galaxy (about cosmic axis if it exists), Hubble's law [15] can be expressed as, $v_G \equiv H_0 d_G$.

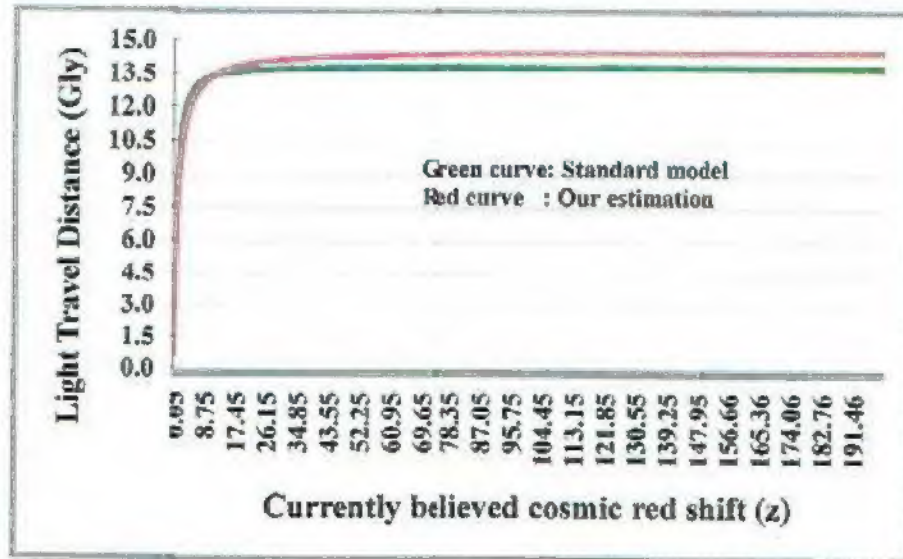


Figure 1. Comparison of standard and estimated light travel distances

3. Our 6 basic assumptions pertaining to cosmic structure and galactic structure

Based on the above points and logics proposed in sections (1) and (2),

- 1) We emphasize the point that, without a radial in-flow of matter in all directions towards any one specific point, it may not be possible to have a big crunch and discussing on center-less universe having a big bang or big bounce seems to be meaningless.
- 2) Considering the evolving universe as a growing black hole or simply a white hole [20,21], it seems natural to expect cosmic rotation.

In this section, considering the current Hubble's constant as an index of current cosmic angular velocity, we propose a simple model of light speed expanding and light speed rotating model of cosmology. It needs a review at fundamental level. Out of 6 assumptions, first four assumptions are associated with cosmic structure and expansion and the last two assumptions are associated with dark matter and galactic structure.

Assumption-1: At present, cosmic angular velocity is equal to the present Hubble constant. Mathematically, at present,

$$\begin{aligned} \omega_0 &\cong H_0 \text{ -----(1A)..Fitting with current data.} \\ \omega_i &\cong H_i \text{ -----(1B)..To be confirmed with further study for } (z+1) > 1100. \end{aligned} \quad (1)$$

Assumption-2: Universe is expanding like a black hole with initial light speed expansion and rotation and finally halted with light speed rotation. Mathematically, at present,

$$R_0 \cong \frac{2GM_0}{c^2} \cong \frac{c}{\omega_0} \quad (2)$$

Assumption-3: Universe is expanding like a black hole with a scaled Hawking's black hole temperature formula. Mathematically, it can be expressed as,

$$\begin{aligned} T_0 &\cong \frac{hc^3}{8\pi k_B G \sqrt{M_{pl} M_0}} \cong \frac{h\sqrt{\omega_0 \omega_{pl}}}{4\pi k_B} \\ \text{where } M_0 &\cong \frac{c^3}{2G\omega_0}, \quad M_{pl} \cong \sqrt{\frac{\hbar c}{G}} \quad \text{and} \quad \omega_{pl} \cong \frac{1}{2} \sqrt{\frac{c^5}{G\hbar}}. \end{aligned} \quad (3)$$

It may be noted that, this assumption certainly helps in eliminating the tension in estimating the magnitude of Hubble parameter.

Assumption-4: Following light speed rotation, at present cosmic expansion is coming to a halt. Considering proton and electron rest masses, in a quantum mechanical approach it can be understood as,

$$\frac{Gm_p m_e}{R_p \omega_0} = \frac{\hbar}{2} \quad (4)$$

where $R_p \cong (0.84184 \text{ to } 0.87680) \text{ fm}$ is the root mean square radius of proton [33].

Assumption-5: There exists no dark matter [34-38] and when baryon mass of any galaxy crosses (180 to 200) million solar masses, galaxy 'as a whole' experiences super gravity [22,26] in such a way that its effective or total mass can be expressed as,

$$\begin{aligned} (M_{Total})_G &\cong \left\{ (M_{baryon})_G + \left[\frac{(M_{baryon})_G^{3/2}}{\sqrt{(M_{limit})_0}} \right] \right\} \dots (\text{without dark matter}) \\ &\cong \left\{ (M_{baryon})_G + (M_{dark})_G \right\} \dots (\text{if there exists dark matter}) \end{aligned} \quad (5)$$

$$\text{where, } \begin{cases} (M_{limit})_0 \cong \text{Current mass limit of ordinary gravity} \\ \quad \quad \quad = 180 \text{ to } 200 \text{ solar masses} \cong (3.6 \text{ to } 4.0) \times 10^{38} \text{ kg.} \\ (M_{baryon})_G = \text{Galactic baryon mass.} \\ (M_{dark})_G = \text{Galactic dark mass.} \\ (M_{Total})_G = \text{Total mass of Galaxy.} \end{cases}$$

Starting from the recombination period, for $(M_{limit})_0$, its current cosmological mass expression can be expressed as,

$$\frac{M_0}{(M_{limit})_0} \cong \exp \left(\sqrt{\frac{T_{Recomb}}{T_0}} \right)$$

$$\text{where } M_0 \cong \frac{c^3}{2G\omega_0} \text{ and } \frac{T_{Recomb}}{T_0} \cong \frac{\text{Recombination temperature}}{\text{Current cosmic temperature}} \cong \frac{3000 \text{ K}}{2.725 \text{ K}}.$$

Assumption-6: Current cosmic mass plays a vital role in understanding the observed galactic flat rotation speeds in such a way that,

$$\frac{V_G}{c} \cong \frac{1}{4} \left[\frac{(M_{Total})_G}{M_0} \right]^{1/4} \quad (6)$$

$$V_G \cong 0.2973 [G(M_{Total})_G (c\omega_0)]^{1/4} \quad (7)$$

It may be noted that, this relation is very similar to the famous MOND's formula [33]. Interesting point to be noted is that $(c\omega_0)$ can be considered as the upper limit of current cosmic acceleration. In addition to that, MOND's concept of weak gravity can be studied in terms of Mach's view on the universal role of cosmic distance back ground [39]. See Fig. 2 for the estimated galactic flat rotation speeds.

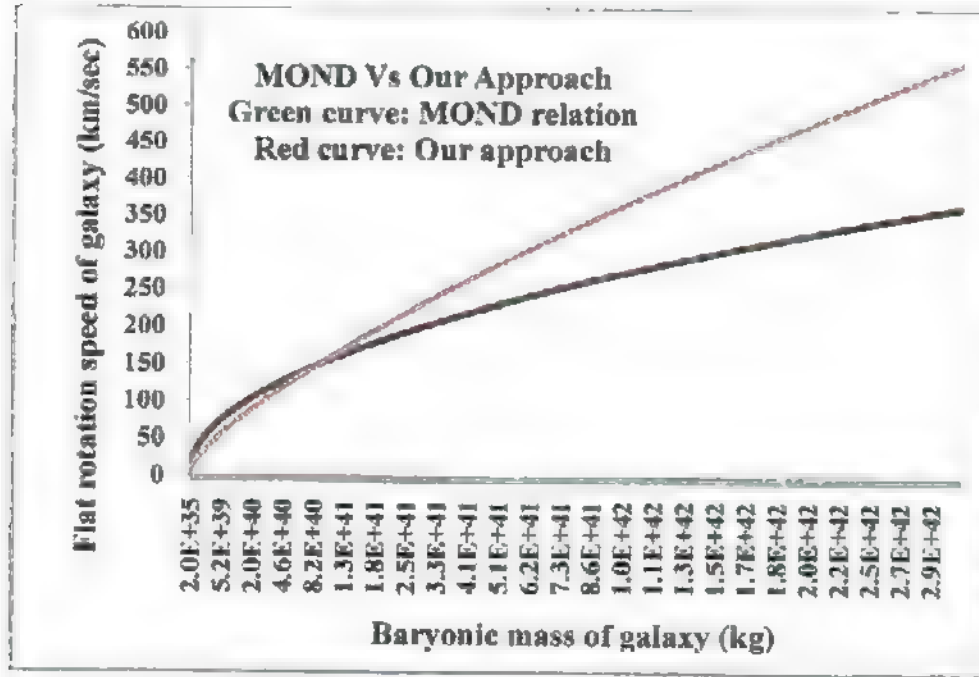


Figure 2: Galactic flat rotation speeds

Flat rotation speeds from 10 km/sec to 500km/sec can be understood in this way. Our proposal is in line with newly discovered dark matter deficient galaxies [40] and large massive galaxies having high flat rotation speeds [41]. Another interesting feature is that, Sun's estimated equivalent dark mass is

around 1.5×10^{26} kg and its effect seems to be negligible. It needs observational and experimental confirmation. To some extent, considering the estimated Virial mass of Sun and based on the theory of light bending, our proposal can be confirmed. Nucleons estimated equivalent dark mass is around 10^{-60} kg and it needs experimental verification.

4. Discussion on present cosmic rotation

Historically, Godel, Gamow, Whittakar, Hawking, Narlikar, Nodland, Ralston, Rubin, Birch, Korotky, Obukhov, Chechin, Sivaram, Magueijo and Longo like many cosmologists expressed their positive opinion on cosmic rotation [7-9],[42-47]. Recent observations on cosmic anisotropy [48] and galactic spin directions seem to support the possible existence of cosmic rotation [49]. Most recent references [12,13,14] seem to shed light on the necessity of considering cosmic positive curvature which is a major prerequisite for cosmic rotation. Even though cosmological principle [50,51] is having 100 years of strong footing, at present, it is being suspected and examined in many directions seriously. It may also be noted that, the argument that the Universe does not rotate is not based on observational evidence, but is merely an assumption that became popular.

It may be noted that, by considering 'light speed rotation' and ignoring 'light speed expansion', Einstein's static universe can be made stable dynamically. There seems no need to introduce the 'Lambda term'. Against to the strongly believed current cosmic acceleration [2], if current universe is having a trend of deceleration as proposed by Paul J. Steinhardt et al and reviewed by Perlmutter S. [1] – by considering light speed rotation throughout the cosmic history- there is a scope for developing light speed rotating and decelerating models of cosmology [18]. We are working on understanding and validating the dual role of light speed in cosmic expansion and rotation. With ongoing observations, whether it is cosmic light speed expansion or light speed rotation - can be explored in all possible ways.

5. Discussion on present cosmic halt

Based on ref. [1], it seems very clear to say that, dark energy is taking a new turn and making the universe to decelerate and within 100 million years, universe is coming to a halt. Here it is very important to note that, so far no

single observation or no single experiment has shown a signal for the existence of dark energy. Cosmologists are somehow making attempts to understand the expanding nature of current universe in terms of dark energy for acceleration as well as deceleration. If it is really true that, in near future, universe is going to a halt, based on assumptions (1) to (4), it can be understood in terms of unification of atomic and cosmic physical constants [52-56]. Relation (4) can be re-written as,

$$\begin{aligned} \frac{Gm_p m_e}{R_p} &= \frac{1}{2} \hbar \omega_0 \text{ --- (8A)} \\ \frac{2Gm_p m_e}{\hbar R_p} &= \omega_0 \approx (67.88 \text{ to } 70.69) \text{ km/sec/Mpc --- (8B)} \\ \text{where } R_p &\approx (0.84184 \text{ to } 0.87680) \text{ fm} \end{aligned} \quad (8)$$

Here in this expression, LHS is a representation of gravitational potential energy of proton and electron separated by a distance equal to the root mean square radius of proton. RHS seems to be a representation of ground state quantum of energy associated with cosmic angular velocity and characteristic quantum constant.

Following relation (4), quantum of orbiting electron's areal velocity can be expressed as,

$$\frac{dA}{dt} \approx \frac{1}{2} v r \approx \frac{Gm_p}{R_p \omega_0} \quad (9)$$

Based on our 4G model of unification [57-60], we noticed that [61],

$$R_p \approx \sqrt{\frac{\alpha_s}{\alpha}} \left(\frac{\hbar}{m_p c} \right) \approx \sqrt{\frac{0.115 \text{ to } 0.12}{0.0073}} \left(\frac{\hbar}{m_p c} \right) \approx (4 \mp 0.05) \left(\frac{\hbar}{m_p c} \right) \approx 4 \left(\frac{\hbar}{m_p c} \right) \quad (10)$$

where α_s is the strong coupling constant and α is the fine structure ratio.

Hence, it is also possible to write another two relations in the following way.

$$\sqrt{\frac{Gm_p^2 m_e c}{2\omega_0}} \cong h \quad (11A)$$

$$\frac{Gm_p^2 m_e c}{2\hbar^2} \cong \omega_0 \cong 70.75 \text{ km/sec/Mpc} \quad (11B)$$

Another very interesting relation is associated with fine structure ratio. For $\omega_0 \cong H_0 \cong 76.266 \text{ km/sec/Mpc}$,

$$\frac{1}{\alpha} \cong \ln \sqrt{\frac{(E_T)_0/2}{(E_{em})_0}} \cong \ln \sqrt{\frac{4\pi\epsilon_0 c^6}{23040\pi G\omega_0^2 e^2}} \cong 137.036 \quad (12)$$

where

$$(E_T)_0 \cong aT_0^4 \left(\frac{4\pi}{3} \left(\frac{c}{\omega_0} \right)^3 \right) \cong \text{Current thermal energy within the current Hubble volume.}$$

$$(E_T)_0 / 2 \cong \text{Half of } aT_0^4 \left(\frac{4\pi}{3} \left(\frac{c}{\omega_0} \right)^3 \right)$$

\cong Current thermal energy within the current hemi spherical or dipole Hubble volume.

$$(E_{em})_0 \cong \frac{e^2}{4\pi\epsilon_0 (c/\omega_0)} \cong \text{Electromagnetic potential associated with current Hubble radius.}$$

Readers are encouraged to refer the URL for various values of the current Hubble parameter estimated with various methods: https://en.wikipedia.org/wiki/Hubble%27s_law. From the data it is clear that, $H_0 \cong (67.6 \text{ to } 76.2) \text{ km/sec/Mpc}$. Relation (12) seems to give a nice picture of the current cosmic closed or positive curvature and it needs a very special study at fundamental level.

6. General discussion on quantum cosmology

Quantum cosmology point of view, our assumptions are very clear and seem to incorporate Planck scale in current cosmic observations. Our assumptions (1) to (4) are giving a very nice explanation for the origin of current cosmic temperature and its observed isotropy on large scales. Proceeding further,

halting of the universe with atomic, nuclear and quantum physical constants seem to open a new branch of cosmology associated with microscopic physics. We are working on finding other such relations. It is well believed that, Hawking's findings about black holes and the universe [62] are the most important contributions to physics in recent decades. Proposed Hawking's scaled black hole temperature formula can be given a chance in understanding and refining the views of Hawking's multi universal paradigm.

1. General discussion on Hubble's law in view of cosmic rotation

Following section (2.4), if one is willing to consider cosmic red shift definition as,

$$z_{new} \equiv \frac{\lambda_{Observed} - \lambda_{Lab}}{\lambda_{Observed}} \approx 1 - \frac{\lambda_{Lab}}{\lambda_{Observed}} \approx \frac{z}{z+1} \quad (13)$$

It will certainly help in understanding and resolving the issues connected with cosmic acceleration and dark energy. Based on this new definition of cosmic red shift, observed farthest galaxies distance can be estimated very easily. For example, see the following Table 1. We sincerely appeal that, on cosmological scales, 2.5% is not yet all a 'serious' error. We would like to emphasize the point that, conceptually, we are no way deviating from the basic idea of cosmic expansion. Only thing is that, we are confining to 'initial light speed expansion and rotation' and 'present light speed rotation with no further expansion'. Whether current/future universe is expanding or not can be understood with,

- a) Rate of decrease in cosmic temperature.
- b) Rate of decrease in Hubble parameter.

Based on the data presented in Tab. 1 Hubble's law for cosmic rotation applicable to whole Hubble volume can be expressed as,

$$d_{H_0} \omega_0 \equiv \left(\frac{z}{z+1} \right) c \approx (z_{new}) c \quad (14)$$

Cosmic scale factor seems to be associated with time and temperature rather than red shift. Scale factor can be expressed as,

$$1+z \cong \sqrt{\exp(\gamma_0 - \gamma_1)} \cong \frac{T_1}{T_0} \quad (15)$$

$$\text{where } \gamma_0 \cong 1 + \ln\left(\frac{\omega_{pl}}{\omega_0}\right) \text{ and } \gamma_1 \cong 1 + \ln\left(\frac{\omega_{pl}}{\omega_1}\right)$$

$T_1, T_0 \cong$ Past and current cosmic temperatures.

Table-1: To estimate and fit the distances of farthest galaxies

Galaxy	Redshift	Standard Light travel distance (Gly)	Estimated Light travel distance (Gly)	%Error
GN-z11	11.09	13.39	13.41	-0.15
MACS1149-JD1	9.11	13.26	13.17	0.65
EGSY8p7	8.68	13.23	13.11	0.91
A2744 YD4	8.38	13.2	13.06	1.05
EGS-zs8-1	7.73	13.13	12.95	1.41
z7 GSD 3811	7.66	13.11	12.93	1.36
z8 GND 5296	7.51	13.1	12.9	1.51
SXDF-NB1006-2	7.215	13.17	12.84	2.5
GN 108036	7.213	13.07	12.84	2.5
BDF-3299	7.109	13.05	12.84	2.5
A1703 zD6	7.014	13.04	12.84	2.5
BDF-521	7.008	13.04	12.84	2.5
G2-1408	6.972	13.03	12.84	2.5
10K-1	6.964	13.03	12.84	2.5

Following our approach, currently believed cosmic time scale up to $1+z=1100$ can be expressed as,

$$t\omega_1 \cong \sqrt{1+z} \quad (16)$$

It is an accurate fit and needs a careful review for its strange matching. We are working in this direction. If so,

$$t \cong \left(\frac{1}{1+z}\right)^{\frac{1}{2}} \left(\frac{1}{H_0}\right) \cong \left(\frac{1}{1+z}\right)^{\frac{1}{2}} \left(\frac{1}{\omega_0}\right) \cong \frac{\sqrt{1+z}}{\omega_1} \cong \frac{[\exp(\gamma_0 - \gamma_1)]^{\frac{1}{4}}}{\omega_1} \quad (17)$$

$$\text{where } \omega_1 \cong \left(\frac{1}{\omega_{pl}}\right) \left(\frac{4\pi k_B T_1}{h}\right)^2 \cong 2 \sqrt{\frac{Gh}{c^2} \left(\frac{4\pi k_B T_1}{h}\right)^2}$$

Interesting observation to be noted is that,

$$\frac{\omega_t}{\omega_0} \equiv \exp(\gamma_0 - \gamma_t) \equiv (1+z)^2 \quad (18)$$

8. Estimation of distances associated with galactic flat rotation speeds

Following assumptions (5) and (6), we suggest the following points for further study and observation.

- 1) Galactic total mass can be considered as the sum of galactic baryonic mass and dark mass.
- 2) As galactic total mass increases, galactic flat rotation speed as well as the distance associated with flat rotation speed increases.
- 3) Galactic core radius seems to depend on galactic baryon mass, current cosmic Hubble mass and the ratio of galactic baryon mass to total mass.
- 4) Galactic flat rotation distance seems to depend on galactic total mass, current cosmic Hubble mass and the ratio of galactic baryon mass to total mass.

Based on these points, we noticed a very simple relation for galactic flat rotation distances. It can be expressed as,

$$\begin{aligned} r_f &\equiv \frac{2G \sqrt{(M_{\text{baryon}})_G M_0}}{c^2} \\ &\equiv \sqrt{\left(\frac{2G(M_{\text{baryon}})_G}{c^2} \right) \left(\frac{c}{\omega_0} \right)} \equiv \sqrt{\frac{2G(M_{\text{baryon}})_G}{c\omega_0}} \end{aligned} \quad (19)$$

$$\text{where } \begin{cases} r_f = \text{Distance from galactic center associated with flat rotation speed.} \\ M_0 \equiv \frac{c^3}{2G\omega_0} = \text{Current cosmic Hubble mass.} \end{cases}$$

Galactic core radius can be expressed as.

$$r_c \cong \sqrt{\frac{M_0}{(M_{total})_G}} \left(\frac{2G(M_{baryon})_G}{c^2} \right) \quad (20)$$

Based on relations (19) and (20),

$$\begin{aligned} \frac{r_f}{r_c} &\equiv \frac{\text{Distance from galactic center associated with flat rotation speed}}{\text{Galactic core radius}} \\ &\cong \sqrt{\frac{(M_{total})_{r_f}}{(M_{baryon})_G}} \cong \sqrt{1 + \frac{(M_{dark})_{r_f}}{(M_{baryon})_G}} \end{aligned} \quad (21)$$

Interesting point to be noted is that, by knowing the galactic flat rotation speed and flat rotation distance, galactic baryon mass, galactic total mass and hence galactic dark mass can be estimated in a unified approach. This is for observational test. Galactic whole radius can be expressed as,

$$R_G \equiv \frac{G(M_{total})_G}{V_G^2} \cong \left(\frac{16G\sqrt{(M_{total})_{r_f} M_0}}{c^2} \right) \cong \sqrt{\frac{128G(M_{total})_G}{c\alpha_0}} \quad (22)$$

It may be noted that, based on relations (19) to (22), galactic masses, flat rotation speeds and corresponding distances can be studied in a unified approach. Estimated baryon and dark masses can be compared with existing methods. Advantage of our approach is that, current cosmic Hubble mass can be considered as a key tool in exploring the structural secrets of galaxies.

See Tab. 2 for galactic masses, flat rotation speeds and working radii. See Fig. 3 for estimated galactic flat rotation distances. Galactic rotation curves for $r \geq r_c$ can be approximated with the following relations. It needs a fine tuning based on the actual curve [63].

Table 2. Galactic masses, flat rotation speeds and working radii

Assumed baryon mass M_{\odot}	Estimated dark mass M_{\odot}	Estimated total mass M_{\odot}	Estimated flat rotation speed (km/sec)	Estimated core radius (kpc)	Estimated flat rotation distance (kpc)	Estimated whole radius (kpc)
5.03E+05	2.51E+04	5.28E+05	4.74	0.014	0.015	0.120
7.54E+05	4.62E+04	8.00E+05	4.82	0.017	0.018	0.148
1.13E+06	8.48E+04	1.22E+06	5.35	0.021	0.022	0.183
1.70E+06	1.56E+05	1.86E+06	5.95	0.026	0.027	0.225
2.55E+06	2.86E+05	2.83E+06	6.61	0.031	0.033	0.279
3.82E+06	5.26E+05	4.34E+06	7.36	0.038	0.040	0.345
5.73E+06	9.66E+05	6.69E+06	8.20	0.046	0.049	0.428
8.59E+06	1.78E+06	1.04E+07	9.15	0.055	0.061	0.533
1.29E+07	3.26E+06	1.61E+07	10.22	0.066	0.074	0.665
1.93E+07	5.99E+06	2.53E+07	11.43	0.079	0.091	0.833
2.90E+07	1.10E+07	4.00E+07	12.82	0.095	0.111	1.047
4.35E+07	2.02E+07	6.37E+07	14.40	0.113	0.136	1.321
6.52E+07	3.72E+07	1.02E+08	16.21	0.133	0.167	1.675
9.78E+07	6.83E+07	1.66E+08	18.30	0.157	0.204	2.134
1.47E+08	1.25E+08	2.72E+08	20.70	0.184	0.250	2.731
2.20E+08	2.30E+08	4.51E+08	23.48	0.214	0.307	3.514
3.30E+08	4.23E+08	7.53E+08	26.71	0.249	0.376	4.544
4.95E+08	7.77E+08	1.27E+09	30.45	0.287	0.460	5.906
7.43E+08	1.43E+09	2.17E+09	34.80	0.330	0.563	7.714
1.11E+09	2.62E+09	3.74E+09	39.86	0.377	0.690	10.122
1.67E+09	4.82E+09	6.49E+09	45.76	0.429	0.845	13.339
2.51E+09	8.86E+09	1.14E+10	52.63	0.486	1.035	17.647
3.76E+09	1.63E+10	2.00E+10	60.64	0.549	1.268	23.430
5.64E+09	2.99E+10	3.55E+10	69.98	0.619	1.553	31.205
8.46E+09	5.49E+10	6.34E+10	80.88	0.695	1.902	41.674
1.27E+10	1.01E+11	1.14E+11	93.57	0.779	2.329	55.789
1.90E+10	1.85E+11	2.04E+11	108.38	0.871	2.852	74.837
2.86E+10	3.40E+11	3.69E+11	125.63	0.972	3.493	100.364
4.28E+10	6.25E+11	6.68E+11	145.74	1.083	4.279	135.333
6.43E+10	1.15E+12	1.21E+12	169.17	1.206	5.240	182.348
9.64E+10	2.11E+12	2.21E+12	196.48	1.341	6.418	245.951
1.45E+11	3.88E+12	4.02E+12	228.28	1.490	7.860	332.024
2.17E+11	7.12E+12	7.34E+12	265.33	1.655	9.627	448.539
3.25E+11	1.31E+13	1.34E+13	308.48	1.836	11.790	606.300
4.88E+11	2.40E+13	2.45E+13	358.74	2.037	14.440	819.950
7.32E+11	4.42E+13	4.49E+13	417.27	2.258	17.685	1109.333
1.10E+12	8.11E+13	8.22E+13	485.43	2.503	21.660	1501.342
1.65E+12	1.49E+14	1.51E+14	564.80	2.773	26.528	2072.429
2.47E+12	2.74E+14	2.76E+14	657.21	3.072	32.490	2751.996

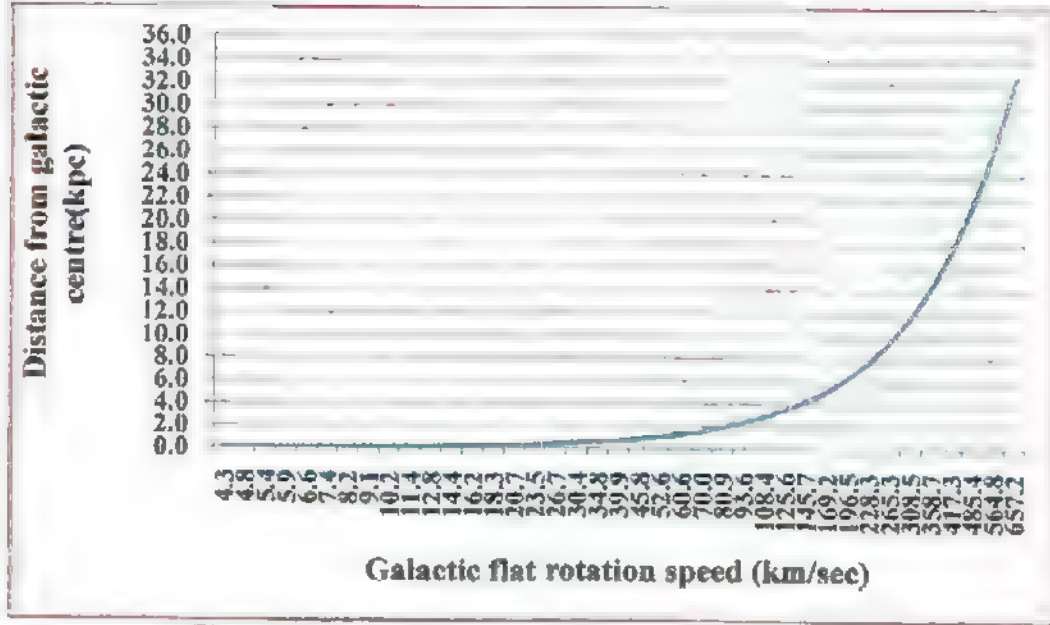


Figure 3: Galactic flat rotation speeds Vs distances

$$\left. \begin{aligned} V_r &\cong \frac{1}{3} \left[1 + \ln \left(\frac{r}{r_c} \right) + \frac{1}{2} \ln \left(\frac{(M_{Total})_G}{(M_{baryon})_G} \right) \right] \left[\frac{G(M_{Total})_G V_{Ref}^2}{r} \right]^{\frac{1}{4}} \quad \text{--- (23A)} \\ V_r &\cong \frac{1}{3} \left[1 + \ln \left(\frac{r}{r_c} \right) + \frac{1}{3} \ln \left(\frac{(M_{Total})_G}{(M_{baryon})_0} \right) \right] \left[\frac{G(M_{Total})_G V_{Ref}^2}{r} \right]^{\frac{1}{4}} \quad \text{--- (23B)} \end{aligned} \right\} \quad (23)$$

$$\text{where } V_{Ref} \cong \left[\frac{G(M_{Ref})_0 c \omega_0}{128} \right]^{\frac{1}{4}} \cong 19.2 \text{ km/sec}$$

$$((M_{limit})_0 \cong 4 \times 10^{38} \text{ kg} = 200 \text{ million solar masses})$$

Thus, the proposed reference mass unit of 200 million solar masses seems to play a crucial role in deciding galactic structures.

See the following Fig. 4 pertaining to estimated Milky Way rotation Curves for 1.4 kpc to 319 kpc [64]. Estimated baryon mass, dark mass and total mass of Milky Way are, $1.2 \times 10^{11} M_\odot$, $2.94 \times 10^{12} M_\odot$ and $3.06 \times 10^{12} M_\odot$ respectively.

Based on relation (23), in terms of galactic core radius and flat rotation distance, galactic rotation curve can be re-expressed as,

$$\left. \begin{aligned} V_r &\approx \frac{1}{3} \left[1 + \ln \left(\frac{r}{r_c} \right) + \ln \left(\frac{r_f}{r_c} \right) \right] \left[\frac{G(M_{total})_G V_{Ref}^2}{r} \right]^{\frac{1}{4}} \text{-----(24A)} \\ V_r &\approx \frac{1}{3} \left[1 + \ln \left(\frac{r}{r_c} \right) + \frac{2}{3} \ln \left(\frac{r_f}{r_c} \right) \right] \left[\frac{G(M_{total})_G V_{Ref}^2}{r} \right]^{\frac{1}{4}} \text{-----(24B)} \end{aligned} \right\} \quad (24)$$

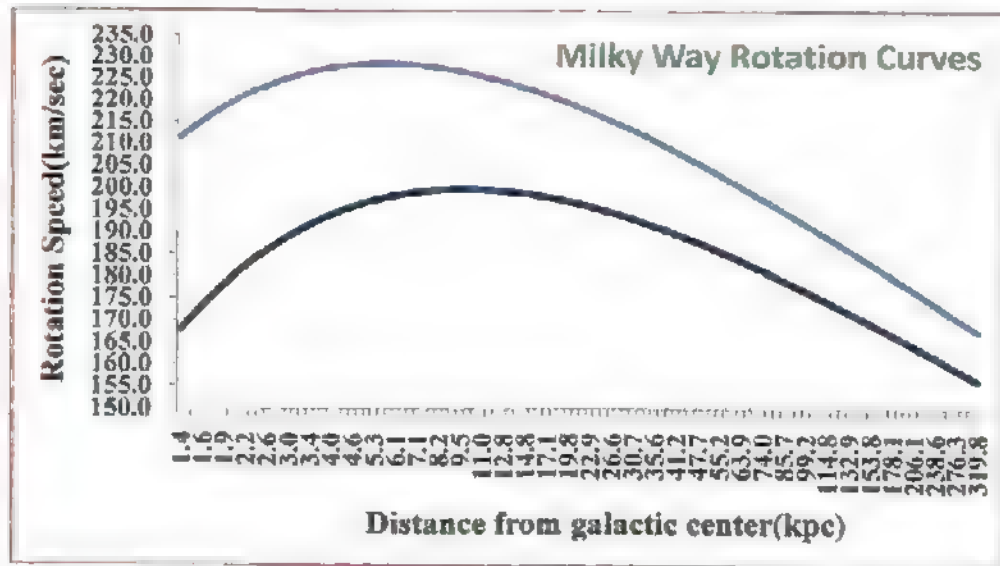


Figure 4: Estimated Milky Way Rotation Curves

Considering relations (19) and (20) and by knowing the galactic flat rotation speeds, galactic total masses and galactic radii can be estimated without the need of currently believed 'dark matter halo' concepts and their complicated analytical procedures.

Based on relations (19) to (24), one can understand the potential applications of current cosmic angular velocity or rotation speed in exploring the constructional secrets of galaxies. It needs further study.

It may be noted that, considering a rotating and expanding model of cosmology, it seems possible to say that,

- 1) Galaxies seem to follow an outward spiral path.
- 2) Galaxies can be seemed to be arranged in a systematic order.
- 3) Even though present universe is believed to be accelerating, as current expansion rate is very small, increase in separation distance between neighboring galaxies seems to be negligible. Hence, distance between neighboring galaxies seems to be approximately fixed.

Based on the new red shift definition as discussed in section (7), various distances associated with galactic light can be understood in the following way.

Light Travel Distance can be approximated with,

$$LTD \cong z_{new} \left(\frac{c}{\omega_0} \right) \quad (25)$$

Comoving Distance can be approximated with,

$$CD \cong \exp(z_{new}) * LTD \quad (26)$$

Hence, Hubble's law for galactic comoving distances can be expressed as,

$$CD_{gal} \cong z_{new} \exp(z_{new}) * \left(\frac{c}{\omega_0} \right) \text{ where } z_{new} \leq 1 \quad (27)$$

For Lambda model of cosmology, corresponding receding speed of a galaxy can be expressed as, $V_{gal} \cong [z_{new} \exp(z_{new})]c = \left[\left(\frac{z}{1+z} \right) \exp \left(\frac{z}{1+z} \right) \right]c$

For $z_{new} \cong 1$, $CD_{gal} \cong \exp(1) * \left(\frac{c}{\omega_0} \right) \cong 2.7183 \left(\frac{c}{\omega_0} \right) \cong 39.74 \text{ Gly.}$

It may be noted that, according to Lambda model of cosmology, radius of observable universe is around 45 Gly.

Luminosity Distance can be approximated with,

$$LD \approx \frac{CD}{1-z_{new}} \approx \left(\frac{z_{new} \exp(z_{new})}{1-z_{new}} \right) \left(\frac{c}{H_0} \right) \quad (28)$$

See Fig. 5 and Table 3. See Appendix A for the C++ program.

Column Details of Table 3

Column-1: Red shift

Column-2: Modified Red shift

Column-3: Light travel distance as per Lambda Cosmology (Gly)

Column-4: Light travel distance in Hubble-Hawking Cosmology (Gly)

Column-5: % error in Light travel distance (Blue curve in the graph)

Column-6: Comoving distance as per Lambda Cosmology (Gly)

Column-7: Comoving distance in Hubble-Hawking Cosmology (Gly)

Column-8: % error in Comoving distance (Red curve in the graph)

Column-9: Luminosity distance as per Lambda Cosmology (Gly)

Column-10: Luminosity distance in Hubble-Hawking Cosmology (Gly)

Column-11: % error in Luminosity distance (Red curve in the graph)

Note-1: LC = Lambda cosmology and HHC = Hubble-Hawking cosmology

Note-2: Numerically, columns 8 and 11 are almost same.

Data values: $H_0 = 66.89$ km/sec/Mpc;

Matter density % = 0.32%;

Dark energy density % = 0.68%

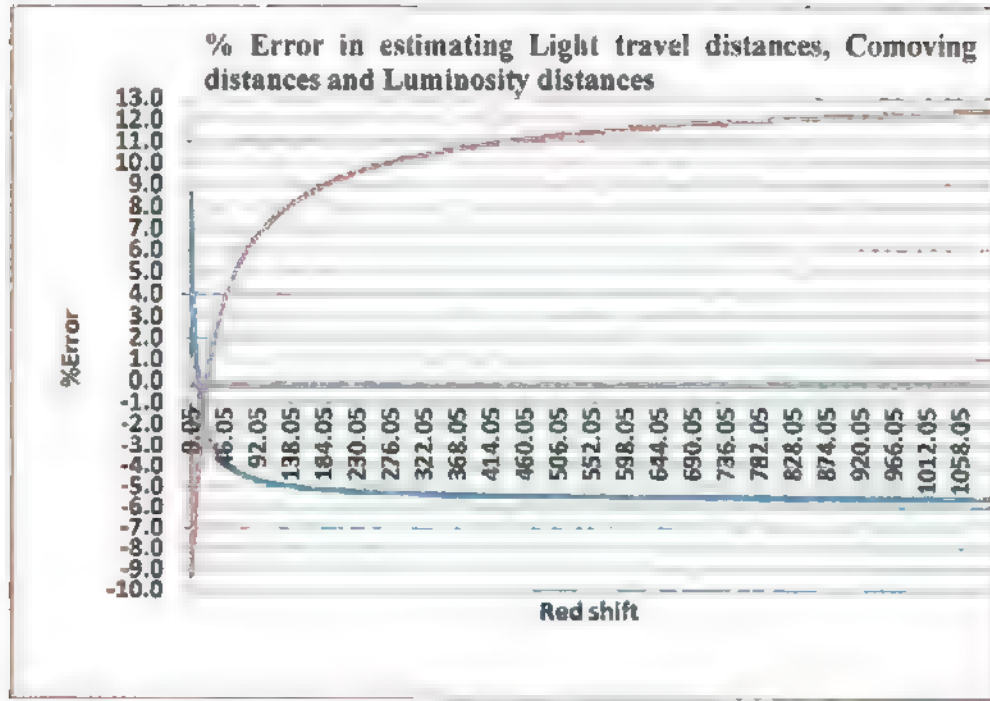


Figure 5: Comparative study of various cosmological distances

Table 3: Various cosmological distances estimated with true cosmic red shift

z	$z(1+z)$	LTD LC	LTD HHC	%Error	CD LC	CD HHC	%Error	LD LC	LD HHC	%Error
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
0.05	0.0508	0.704	0.696	1.174	0.723	0.730	-1.130	0.76	0.767	-1.140
1.05	2.112	8.183	7.167	8.558	11.533	15.405	-8.553	53.67	54.65	-8.553
		11.54	7.6	33.8	1.7	4.8	-6.21	54.3	58.69	-7
2.1	5.52	11.715	11.028	6.197	21.335	21.376	-0.059	86.81	94.674	-8.040
		12.2	1.723	-8.75	54.353	5.142	-6.557	17.14	1.004	-28.54
3.05	9.335	12.681	12.501	1.783	26.056	28.114	-7.658	17.44	2.385	-8.68
		12.7	1.684	-2.827	2.299	4.89	-21	1.337	2.57	-2.53
		11.83	12.722	5.167	28.87	6.75	-1.49	37.7	74.4	-4.50
4.05	13.305	11.763	11.705	1.556	29.973	11.648	-24.93	27.125	29.330	-8.14
		12.8	11.161	10.9	40.748	1.092	-2.34	0.117	72.47	-5.14
		13.17	13.295	0.545	31.501	31.07	-4.994	348.09	344.76	-0.974
7	13.424	13.104	13.104	0.140	31.158	13.535	-4.383	387.50	4.38	-8.76
		13.7	13.7	0	3.25	2.8	-1.7	4.76	4.24	-1.11
		13.75	1	-2.7	33.7	11.5	-1.57	1.22	182.00	-1.158
		13.7	13.7	0	33.88	13.8	-1.5	2.5	285.56	-1.5
		13.569	17.57	27.7	34.4	31.06	-2.5	34.4	41.1	-2.3
		13.5	1.08	-2.12	33.28	1.273	-2.82	38.7	65.17	-2.53
		13.5	13.409	1.111	1.83	15.53	-8.18	67.3	69.047	-2.8
		13.576	13.440	-1.026	34.108	34.723	-1.493	670.52	109.26	-4.75
		13.58	13.58	0	34.3	3.866	-8	71.33	737	-8.9
		13.7	13.21	0.46	15.771	36.6	-58	743.66	74.7	-8.96
		13	13.35	2.68	28.35	46.51	-27	4.5	78.4	-7.2
		13.7	13.7	0	20.503	36.21	-25.1	85.35	3.8123	-9.5
		13.86	41.70	2.31	16.494	36.521	-4.101	877.60	876.974	-0.07
		13.88	13.34	5.43	36.711	16.644	-0.152	919.61	9.82	-9.9
		13.77	13.67	-0.7	40	36.770	-0.304	93.41	95.7850	-2.54
20.2	11.13	13.7	13.7	2.656	17.62	16.877	-1.84	76.11	69.4	-9.52
27.35	0.961	13.719	14.096	2.736	17.567	16.976	-0.763	148.35	102.173	-3.782
		13.726	14.114	-2.932	37.446	3.608	-1.804	1087.41	1079.930	-0.699

(1)	(2)	LTD LC	LTD HHC	%Error	CD LC	CD HHC	%Error	LD LC	LD HHC	%Error
29.35	0.967	13.731	14.131	-2.915	37.600	37.155	1.184	1129.87	1116.500	1.184
30.05	0.968	13.736	14.147	-2.991	37.756	37.236	1.378	1172.33	1156.170	1.378
3.05	0.969	13.750	14.161	-3.064	37.901	37.312	1.559	1214.71	1195.850	1.555
		13.744	14.155	-3.134	38.035	37.384	1.678	1256.55	1235.54	1.66
		13.748	14.168	-3.198	38.167	37.451	1.874	1299.57	1275.210	1.874
14.05	0.971	13.752	14.200	-3.258	38.303	37.515	2.056	1342.50	1314.900	2.056
		13.756	14.212	-3.316	38.425	37.575	2.212	1385.24	1354.34	2.212
		13.760	14.223	-3.371	38.544	37.632	2.341	1427.4	1394.284	2.340
		13.763	14.231	-3.423	38.661	37.688	2.471	1469.4	1434.670	2.470
18.05	0.974	13.765	14.243	-3.476	38.756	37.738	2.627	1511.42	1473.660	2.627
		13.767	14.250	-3.525	38.853	37.787	2.744	1553.45	1511.660	2.744
40.05	0.976	13.770	14.261	-3.572	38.951	37.833	2.860	1595.03	1553.060	2.860
		13.772	14.268	-3.615	39.046	37.876	2.992	1636.45	1594.77	2.992
	0.977	13.774	14.278	-3.650	39.151	37.920	3.143	1678.44	1632.460	3.143
		13.776	14.286	-3.688	39.245	37.966	3.290	1719.47	1673.47	3.290
		13.778	14.293	-3.727	39.338	37.990	3.461	1760.45	1714.47	3.461
		13.780	14.300	-3.761	39.428	38.014	3.648	1801.42	1755.45	3.648
		13.781	14.307	-3.791	39.515	38.038	3.856	1842.37	1796.42	3.856
		13.783	14.314	-3.818	39.600	38.061	4.090	1883.30	1837.37	4.090
	0.980	13.785	14.320	-3.842	39.683	38.084	4.348	1924.21	1878.30	4.348
		13.786	14.325	-3.863	39.764	38.106	4.630	1965.10	1919.21	4.630
		13.788	14.331	-3.881	39.843	38.127	4.936	2006.00	1960.10	4.936
		13.789	14.337	-3.897	39.920	38.147	5.266	2046.90	2001.00	5.266
		13.790	14.342	-3.910	39.995	38.166	5.620	2087.80	2041.90	5.620
		13.791	14.347	-3.920	40.067	38.184	5.998	2128.70	2082.80	5.998
		13.792	14.352	-3.928	40.137	38.201	6.400	2169.60	2123.70	6.400
		13.793	14.357	-3.934	40.205	38.217	6.826	2210.50	2164.60	6.826
		13.794	14.361	-3.938	40.271	38.232	7.276	2251.40	2205.50	7.276
		13.795	14.366	-3.940	40.335	38.246	7.750	2292.30	2246.40	7.750
		13.796	14.370	-3.941	40.397	38.259	8.248	2333.20	2287.30	8.248
		13.797	14.374	-3.941	40.458	38.271	8.770	2374.10	2328.20	8.770
		13.798	14.378	-3.940	40.517	38.282	9.316	2415.00	2369.10	9.316
60.05	0.984	13.799	14.378	-3.938	40.575	38.292	9.886	2455.90	2410.00	9.886
		13.800	14.382	-3.935	40.631	38.302	10.480	2496.80	2450.90	10.480
		13.801	14.386	-3.930	40.686	38.311	11.098	2537.70	2491.80	11.098
		13.802	14.389	-3.924	40.739	38.319	11.740	2578.60	2532.70	11.740
		13.803	14.392	-3.917	40.790	38.326	12.406	2619.50	2573.60	12.406
		13.804	14.395	-3.909	40.839	38.333	13.096	2660.40	2614.50	13.096
		13.805	14.398	-3.900	40.886	38.339	13.810	2701.30	2655.40	13.810
		13.806	14.401	-3.890	40.931	38.344	14.548	2742.20	2696.30	14.548
		13.807	14.404	-3.879	40.974	38.348	15.310	2783.10	2737.20	15.310
		13.808	14.407	-3.867	41.016	38.351	16.096	2824.00	2778.10	16.096
		13.809	14.410	-3.854	41.057	38.353	16.906	2864.90	2819.00	16.906
		13.810	14.413	-3.840	41.097	38.355	17.740	2905.80	2859.90	17.740
		13.811	14.416	-3.825	41.136	38.356	18.598	2946.70	2900.80	18.598
		13.812	14.419	-3.809	41.173	38.357	19.480	2987.60	2941.70	19.480
		13.813	14.422	-3.792	41.209	38.357	20.386	3028.50	2982.60	20.386
		13.814	14.425	-3.774	41.244	38.357	21.316	3069.40	3023.50	21.316
		13.815	14.428	-3.755	41.277	38.356	22.270	3110.30	3064.40	22.270
		13.816	14.431	-3.735	41.309	38.355	23.248	3151.20	3105.30	23.248
		13.817	14.434	-3.714	41.340	38.353	24.250	3192.10	3146.20	24.250
		13.818	14.437	-3.692	41.369	38.351	25.276	3233.00	3187.10	25.276
		13.819	14.440	-3.669	41.397	38.348	26.326	3273.90	3228.00	26.326
		13.820	14.443	-3.645	41.424	38.345	27.400	3314.80	3268.90	27.400
		13.821	14.446	-3.620	41.450	38.341	28.498	3355.70	3309.80	28.498
		13.822	14.449	-3.594	41.475	38.337	29.620	3396.60	3350.70	29.620
		13.823	14.452	-3.567	41.500	38.332	30.766	3437.50	3391.60	30.766
		13.824	14.455	-3.539	41.523	38.327	31.936	3478.40	3432.50	31.936
		13.825	14.458	-3.510	41.546	38.321	33.130	3519.30	3473.40	33.130
		13.826	14.461	-3.480	41.568	38.315	34.348	3560.20	3514.30	34.348
		13.827	14.464	-3.449	41.589	38.308	35.590	3601.10	3555.20	35.590
		13.828	14.467	-3.417	41.609	38.301	36.856	3642.00	3596.10	36.856
		13.829	14.470	-3.384	41.628	38.294	38.146	3682.90	3637.00	38.146
		13.830	14.473	-3.350	41.646	38.286	39.460	3723.80	3677.90	39.460
		13.831	14.476	-3.315	41.663	38.278	40.798	3764.70	3718.80	40.798
		13.832	14.479	-3.279	41.679	38.269	42.160	3805.60	3759.70	42.160
		13.833	14.482	-3.242	41.694	38.260	43.546	3846.50	3800.60	43.546
		13.834	14.485	-3.204	41.708	38.250	44.956	3887.40	3841.50	44.956
		13.835	14.488	-3.165	41.721	38.240	46.390	3928.30	3882.40	46.390
		13.836	14.491	-3.125	41.734	38.229	47.848	3969.20	3923.30	47.848
		13.837	14.494	-3.084	41.746	38.218	49.330	4010.10	3964.20	49.330
		13.838	14.497	-3.042	41.757	38.206	50.836	4051.00	4005.10	50.836
		13.839	14.500	-3.000	41.768	38.194	52.366	4091.90	4046.00	52.366
		13.840	14.503	-2.957	41.778	38.181	53.920	4132.80	4086.90	53.920
		13.841	14.506	-2.913	41.787	38.168	55.498	4173.70	4127.80	55.498
		13.842	14.509	-2.868	41.796	38.155	57.100	4214.60	4168.70	57.100
		13.843	14.512	-2.822	41.805	38.141	58.726	4255.50	4209.60	58.726
		13.844	14.515	-2.775	41.813	38.127	60.376	4296.40	4250.50	60.376
		13.845	14.518	-2.727	41.821	38.112	62.050	4337.30	4291.40	62.050
		13.846	14.521	-2.679	41.828	38.097	63.748	4378.20	4332.30	63.748
		13.847	14.524	-2.630	41.835	38.081	65.470	4419.10	4373.20	65.470
		13.848	14.527	-2.580	41.842	38.065	67.216	4460.00	4414.10	67.216
		13.849	14.530	-2.529	41.848	38.048	68.986	4500.90	4455.00	68.986
		13.850	14.533	-2.477	41.854	38.031	70.780	4541.80	4495.90	70.780
		13.851	14.536	-2.425	41.860	38.014	72.598	4582.70	4536.80	72.598
		13.852	14.539	-2.372	41.865	37.996	74.440	4623.60	4577.70	74.440
		13.853	14.542	-2.319	41.870	37.978	76.306	4664.50	4618.60	76.306
		13.854	14.545	-2.265	41.875	37.959	78.196	4705.40	4659.50	78.196
		13.855	14.548	-2.211	41.880	37.940	80.110	4746.30	4700.40	80.110
		13.856	14.551	-2.156	41.885	37.921	82.048	4787.20	4741.30	82.048
		13.857	14.554	-2.101	41.889	37.901	84.010	4828.10	4782.20	84.010
		13.858	14.557	-2.045	41.893	37.881	85.996	4869.00	4823.10	85.996
		13.859	14.560	-1.989	41.897	37.860	88.006	4909.90	4864.00	88.006
		13.860	14.563	-1.932	41.901	37.839	90.040	4950.80	4904.90	90.040
		13.861	14.566	-1.875	41.905	37.817	92.098	4991.70	4945.80	92.098
		13.862	14.569	-1.817	41.908	37.795	94.180	5032.60	4986.70	94.180
		13.863	14.572	-1.759	41.912	37.773	96.286	5073.50	5027.60	96.286
		13.864	14.575	-1.700	41.915	37.750	98.416	5114.40	5068.50	98.416
		13.865	14.578	-1.641	41.918	37.727	100.570	5155.30	5109.40	100.570
		13.866	14.581	-1.581	41.921	37.704	102.748	5196.20	5150.30	102.748
		13.867	14.584	-1.521	41.924	37.681	104.950	5237.10	5191.20	104.950
		13.868	14.587	-1.460	41.927	37.657	107.176	5278.00	5232.10	107.176
		13.869	14.590	-1.399	41.930	37.633	109.426	5318.90	5273.00	109.426
		13.870	14.593	-1.337	41.933	37.608	111.690	5359.80	5313.90	111.690
		13.871	14.596	-1.275	41.936	37.583	113.978	5400.70	5354.80	113.978
		13.872	14.599	-1.212	41.939	37.558	116.290	5441.60	5395.70	116.290
		13.873	14.602	-1.149	41.942	37.532	118.626	5482.50	5436.60	118.626
		13.874	14.605	-1.086	41.945	37.506	120.986	5523.		

Z	σ	LTD LC	LTD HHC	%Error	CD LC	CD HHC	%Error	ID LC	ID HHC	%Error
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		13 8 7	14 467	4 705	4 754	-8 222	761		3355 34	6 78
		13 8 7	14 468	-4 714	4 758	35 3	6 8 7	35 33	38 7 8	6 817
0.5	0.000	13 817	14 470	-4 723	41 803	38 938	6 854	4140 61	3856 820	6 854
0.5	0.000	13 818	14 471	-4 732	41 829	38 946	6 892	4184 96	3896 550	6 892
		13 818	14 474	-4 740	41 834	38 954	6 906	422 17	3916 367	6 930
0.05	0.990	13 818	14 474	-4 749	41 880	38 961	6 969	4273 84	3975 990	6 969
0.05	0.990	13 818	14 476	-4 757	41 906	38 969	7 008	4318 38	4015 710	7 009
		13 819	14 477	-4 765	41 931	38 976	7 049	436 36	4055 450	7 049
		13 819	14 478	-4 773	41 958	38 983	7 088	440 36	4095 380	7 089
		13 8 9	14 480	-4 781	41 984	38 991	7 13	444 38	4135 300	7 130
		13 8 9	14 481	-4 789	42 010	38 997	7 172	448 38	4175 220	7 172
		13 8 9	14 482	-4 797	42 036	38 999	7 210	452 38	4215 140	7 210
0.835	0.991	13 820	14 483	-4 804	42 037	39 011	7 199	4584 08	4254 900	7 199
0.935	0.991	13 820	14 485	-4 811	42 063	39 017	7 242	4629 05	4294 820	7 242
0.935	0.991	13 820	14 486	-4 818	42 090	39 024	7 285	4674 08	4334 560	7 285
0.935	0.991	13 820	14 487	-4 824	42 117	39 030	7 330	4719 18	4374 280	7 330
		13 82	14 488	-4 831	42 144	39 036	7 374	4764 35	4414 000	7 374
		13 82	14 489	-4 839	42 170	39 042	7 417	4809 45	4453 720	7 417
		13 82	14 490	-4 845	42 196	39 048	7 458	4854 55	4493 440	7 458
		13 82	14 491	-4 851	42 222	39 054	7 499	4899 65	4533 160	7 499
0.05	0.991	13 821	14 493	-4 857	42 226	39 060	7 498	4944 52	4572 900	7 498
		13 82	14 494	-4 864	42 252	39 066	7 485	4989 45	4612 650	7 485
		13 82	14 495	-4 870	42 278	39 071	7 482	5034 35	4652 400	7 482
		13 82	14 496	-4 877	42 304	39 077	7 480	5079 25	4692 150	7 480
0.05	0.992	13 822	14 497	-4 884	42 331	39 082	7 467	5124 14	4731 900	7 467
		13 82	14 498	-4 890	42 357	39 088	7 464	5169 05	4771 650	7 464
0.05	0.992	13 822	14 499	-4 895	42 383	39 092	7 464	5213 95	4811 400	7 464
		13 822	14 500	-4 901	42 409	39 098	7 462	5258 85	4851 150	7 462
		13 822	14 501	-4 907	42 435	39 103	7 460	5303 75	4890 900	7 460
0.05	0.992	13 823	14 502	-4 912	42 461	39 108	7 452	5348 65	4930 650	7 452
		13 823	14 503	-4 918	42 487	39 114	7 449	5393 55	4970 400	7 449
		13 823	14 504	-4 924	42 513	39 119	7 447	5438 45	5010 150	7 447
		13 823	14 505	-4 930	42 539	39 125	7 444	5483 35	5049 900	7 444
		13 823	14 506	-4 936	42 565	39 130	7 442	5528 25	5089 650	7 442
		13 823	14 507	-4 942	42 591	39 136	7 440	5573 15	5129 400	7 440
		13 823	14 508	-4 948	42 617	39 141	7 438	5618 05	5169 150	7 438
		13 823	14 509	-4 954	42 643	39 147	7 436	5662 95	5208 900	7 436
		13 823	14 510	-4 960	42 669	39 152	7 434	5707 85	5248 650	7 434
0.05	0.993	13 824	14 511	-4 965	42 695	39 157	7 432	5752 75	5288 400	7 432
0.05	0.993	13 824	14 512	-4 971	42 721	39 163	8 067	5797 65	5328 150	8 067
0.05	0.993	13 824	14 513	-4 978	42 747	39 168	8 058	5842 55	5367 900	8 058
0.05	0.993	13 824	14 514	-4 984	42 773	39 174	8 104	5887 45	5407 650	8 104
0.05	0.993	13 825	14 515	-4 991	42 799	39 179	8 150	5932 35	5447 400	8 150
0.05	0.993	13 825	14 516	-4 996	42 825	39 185	8 150	5977 25	5487 150	8 150
		13 825	14 517	-5 002	42 851	39 190	8 198	6022 15	5526 900	8 198
0.05	0.993	13 825	14 518	-5 008	42 877	39 196	8 255	6067 05	5566 650	8 255
0.05	0.993	13 825	14 519	-5 014	42 903	39 201	8 246	6111 95	5606 400	8 246
0.05	0.993	13 825	14 520	-5 021	42 929	39 207	8 296	6156 85	5646 150	8 296
0.05	0.993	13 825	14 521	-5 027	42 955	39 212	8 346	6201 75	5685 900	8 346
0.05	0.993	13 825	14 522	-5 034	42 981	39 218	8 396	6246 65	5725 650	8 396
		13 826	14 523	-5 040	43 007	39 223	8 446	6291 55	5765 400	8 446
		13 826	14 524	-5 046	43 033	39 229	8 496	6336 45	5805 150	8 496
		13 826	14 525	-5 053	43 059	39 234	8 546	6381 35	5844 900	8 546
		13 826	14 526	-5 059	43 085	39 240	8 596	6426 25	5884 650	8 596
		13 826	14 527	-5 066	43 111	39 245	8 646	6471 15	5924 400	8 646
0.05	0.994	13 826	14 528	-5 073	43 137	39 251	8 696	6516 05	5964 150	8 696
0.05	0.994	13 826	14 529	-5 079	43 163	39 256	8 746	6560 95	6003 900	8 746

(1)	(2)	LTD LC	LTD HHC	%Error	CD LC	CD HHC	%Error	LD LC	LD HHC	%Error
63.05	0.994	13.826	14.528	-5.077	42.940	39.252	8.588	7044.25	6439.300	8.588
64.05	0.994	13.826	14.529	-5.081	42.940	39.255	8.581	7087.19	6479.050	8.581
65.05	0.994	13.827	14.529	-5.083	42.72	39.258	8.584	7128.55	6520.700	8.584
66.05	0.994	13.827	14.530	-5.087	42.972	39.261	8.637	7178.49	6558.520	8.637
67.05	0.994	13.827	14.530	-5.091	42.772	39.264	8.630	7227.46	6598.200	8.631
68.05	0.994	13.827	14.531	-5.093	43.005	39.266	8.693	7269.96	6637.970	8.693
69.05	0.994	13.827	14.532	-5.097	43.005	39.269	8.687	7312.97	6677.730	8.687
70.05	0.994	13.827	14.532	-5.098	43.18	39.271	8.745	7354.40	6717.490	8.745
71.05	0.994	13.827	14.533	-5.102	43.038	39.274	8.744	7404.65	6757.130	8.745
72.05	0.994	13.827	14.533	-5.106	43.38	39.277	8.716	7454.15	6796.770	8.718
73.05	0.994	13.827	14.533	-5.108	43.071	39.280	8.803	7496.51	6836.630	8.803
74.05	0.994	13.827	14.534	-5.12	43.47	39.282	8.712	7546.58	6876.490	8.716
75.05	0.994	13.827	14.534	-5.15	43.7	39.285	8.711	7596.65	6916.350	8.711
76.05	0.994	13.827	14.535	-5.17	43.4	39.287	8.876	7646.64	6956.210	8.876
77.05	0.994	13.827	14.535	-5.120	43.5	39.288	8.83	7696.70	6996.070	8.830
78.05	0.994	13.827	14.536	-5.124	43.45	39.292	8.814	7746.77	7035.930	8.814
79.05	0.994	13.827	14.536	-5.127	43.45	39.295	8.844	7796.84	7075.790	8.844
80.05	0.994	13.827	14.537	-5.129	43.48	39.297	8.844	7846.91	7115.650	8.844
81.05	0.994	13.828	14.537	-5.132	43.38	39.299	8.880	7896.98	7155.510	8.880
82.05	0.994	13.828	14.538	-5.14	43.38	39.302	8.892	7947.05	7195.370	8.892
83.05	0.994	13.828	14.538	-5.17	43.72	39.304	8.901	7997.12	7235.230	8.901
84.05	0.994	13.828	14.538	-5.130	43.32	39.307	8.955	8047.19	7275.090	8.955
85.05	0.994	13.828	14.539	-5.143	43.72	39.309	8.10	8097.26	7314.950	8.10
86.05	0.994	13.828	14.539	-5.145	43.72	39.311	8.10	8147.33	7354.810	8.10
87.05	0.994	13.828	14.539	-5.148	43.72	39.313	8.10	8197.40	7394.670	8.10
88.05	0.994	13.828	14.540	-5.14	43.207	39.316	8.10	8247.47	7434.530	8.10
89.05	0.994	13.828	14.541	-5.143	43.37	39.318	8.10	8297.54	7474.390	8.10
90.05	0.994	13.828	14.541	-5.145	43.22	39.320	8.10	8347.61	7514.250	8.10
91.05	0.994	13.828	14.541	-5.148	43.32	39.322	8.10	8397.68	7554.110	8.10
92.05	0.994	13.828	14.542	-5.161	43.22	39.324	8.10	8447.75	7593.970	8.10
93.05	0.994	13.828	14.542	-5.164	43.22	39.326	8.10	8497.82	7633.830	8.10
94.05	0.994	13.828	14.543	-5.165	43.22	39.328	8.10	8547.89	7673.690	8.10
95.05	0.994	13.828	14.543	-5.168	43.22	39.330	8.10	8597.96	7713.550	8.10
96.05	0.994	13.828	14.544	-5.172	43.22	39.332	8.10	8648.03	7753.410	8.10
97.05	0.994	13.828	14.544	-5.175	43.22	39.334	8.10	8698.10	7793.270	8.10
98.05	0.994	13.828	14.544	-5.177	43.22	39.336	8.10	8748.17	7833.130	8.10
99.05	0.994	13.828	14.545	-5.180	43.22	39.338	8.10	8798.24	7872.990	8.10
100.05	0.994	13.829	14.545	-5.181	43.348	39.342	8.240	8848.31	7912.850	8.240
101.05	0.994	13.829	14.545	-5.184	43.348	39.344	8.245	8898.38	7952.710	8.245
102.05	0.994	13.829	14.546	-5.186	43.348	39.346	8.245	8948.45	7992.570	8.245
103.05	0.994	13.829	14.546	-5.189	43.348	39.348	8.245	8998.52	8032.430	8.245
104.05	0.994	13.829	14.547	-5.192	43.348	39.350	8.245	9048.59	8072.290	8.245
105.05	0.994	13.829	14.547	-5.195	43.348	39.352	8.245	9098.66	8112.150	8.245
106.05	0.994	13.829	14.548	-5.197	43.348	39.354	8.245	9148.73	8152.010	8.245
107.05	0.994	13.829	14.548	-5.199	43.348	39.356	8.245	9198.80	8191.870	8.245
108.05	0.994	13.829	14.548	-5.201	43.348	39.358	8.245	9248.87	8231.730	8.245
109.05	0.994	13.829	14.549	-5.203	43.348	39.360	8.245	9298.94	8271.590	8.245
110.05	0.994	13.829	14.549	-5.205	43.348	39.362	8.245	9349.01	8311.450	8.245
111.05	0.994	13.829	14.549	-5.207	43.348	39.364	8.245	9399.08	8351.310	8.245
112.05	0.994	13.829	14.549	-5.209	43.348	39.366	8.245	9449.15	8391.170	8.245
113.05	0.994	13.829	14.549	-5.211	43.348	39.368	8.245	9499.22	8431.030	8.245
114.05	0.994	13.829	14.550	-5.213	43.348	39.370	8.245	9549.29	8470.890	8.245
115.05	0.994	13.829	14.550	-5.215	43.348	39.372	8.245	9599.36	8510.750	8.245
116.05	0.994	13.829	14.551	-5.218	43.348	39.374	8.245	9649.43	8550.610	8.245
117.05	0.994	13.829	14.551	-5.220	43.348	39.376	8.245	9699.50	8590.470	8.245
118.05	0.994	13.829	14.551	-5.222	43.348	39.378	8.245	9749.57	8630.330	8.245
119.05	0.994	13.829	14.552	-5.225	43.348	39.380	8.245	9799.64	8670.190	8.245
120.05	0.994	13.829	14.552	-5.227	43.348	39.382	8.245	9849.71	8710.050	8.245
121.05	0.994	13.829	14.553	-5.228	43.348	39.384	8.245	9899.78	8749.910	8.245
122.05	0.994	13.829	14.553	-5.230	43.348	39.386	8.245	9949.85	8789.770	8.245
123.05	0.994	13.829	14.553	-5.232	43.348	39.388	8.245	9999.92	8829.630	8.245
124.05	0.994	13.829	14.553	-5.234	43.348	39.390	8.245	10049.99	8869.490	8.245
125.05	0.994	13.829	14.554	-5.237	43.348	39.392	8.245	10099.06	8909.350	8.245
126.05	0.994	13.829	14.554	-5.237	43.348	39.394	8.245	10149.13	8949.210	8.245
127.05	0.994	13.829	14.554	-5.237	43.348	39.396	8.245	10199.20	8989.070	8.245
128.05	0.994	13.829	14.554	-5.237	43.348	39.398	8.245	10249.27	9028.930	8.245
129.05	0.994	13.829	14.554	-5.237	43.348	39.400	8.245	10299.34	9068.790	8.245
130.05	0.994	13.829	14.554	-5.237	43.348	39.402	8.245	10349.41	9108.650	8.245
131.05	0.994	13.829	14.554	-5.237	43.348	39.404	8.245	10399.48	9148.510	8.245
132.05	0.994	13.829	14.554	-5.237	43.348	39.406	8.245	10449.55	9188.370	8.245
133.05	0.994	13.829	14.554	-5.237	43.348	39.408	8.245	10499.62	9228.230	8.245
134.05	0.994	13.829	14.554	-5.237	43.348	39.410	8.245	10549.69	9268.090	8.245
135.05	0.994	13.829	14.554	-5.237	43.348	39.412	8.245	10599.76	9307.950	8.245
136.05	0.994	13.829	14.554	-5.237	43.348	39.414	8.245	10649.83	9347.810	8.245
137.05	0.994	13.829	14.554	-5.237	43.348	39.416	8.245	10699.90	9387.670	8.245
138.05	0.994	13.829	14.554	-5.237	43.348	39.418	8.245	10749.97	9427.530	8.245
139.05	0.994	13.829	14.554	-5.237	43.348	39.420	8.245	10799.04	9467.390	8.245
140.05	0.994	13.829	14.554	-5.237	43.348	39.422	8.245	10849.11	9507.250	8.245
141.05	0.994	13.829	14.554	-5.237	43.348	39.424	8.245	10899.18	9547.110	8.245
142.05	0.994	13.829	14.554	-5.237	43.348	39.426	8.245	10949.25	9586.970	8.245
143.05	0.994	13.829	14.554	-5.237	43.348	39.428	8.245	10999.32	9626.830	8.245
144.05	0.994	13.829	14.554	-5.237	43.348	39.430	8.245	11049.39	9666.690	8.245
145.05	0.994	13.829	14.554	-5.237	43.348	39.432	8.245	11099.46	9706.550	8.245
146.05	0.994	13.829	14.554	-5.237	43.348	39.434	8.245	11149.53	9746.410	8.245
147.05	0.994	13.829	14.554	-5.237	43.348	39.436	8.245	11199.60	9786.270	8.245
148.05	0.994	13.829	14.554	-5.237	43.348	39.438	8.245	11249.67	9826.130	8.245
149.05	0.994	13.829	14.554	-5.237	43.348	39.440	8.245	11299.74	9865.990	8.245
150.05	0.994	13.829	14.554	-5.237	43.348	39.442	8.245	11349.81	9905.850	8.245
151.05	0.994	13.829	14.554	-5.237	43.348	39.444	8.245	11399.88	9945.710	8.245
152.05	0.994	13.829	14.554	-5.237	43.348	39.446	8.245	11449.95	9985.570	8.245
153.05	0.994	13.829	14.554	-5.237	43.348	39.448	8.245	11499.02	10025.430	8.245
154.05	0.994	13.829	14.554	-5.237	43.348	39.450	8.245	11549.09	10065.290	8.245
155.05	0.994	13.829	14.554	-5.237	43.348	39.452	8.245	11599.16	10105.150	8.245
156.05	0.994	13.829	14.554	-5.237	43.348	39.454	8.245	11649.23	10145.010	8.245
157.05	0.994	13.829	14.554	-5.237	43.348	39.456	8.245	11699.30	10184.870	8.245
158.05	0.994	13.829	14.554	-5.237	43.348	39.458	8.245	11749.37	10224.730	8.245
159.05	0.994	13.829	14.554	-5.237	43.348	39.460	8.245	11799.44	10264.590	8.245
160.05	0.994	13.829	14.554	-5.237	43.348					

Z	z/(1-z)	LTD LC	LTD HHC	%Error	CD LC	CD HHC	%Error	LD LC	LD HHC	%Error
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		1.810	14.554	-5.219	43.544	39.301	-9.550	1010.30	9101.380	-9.589
		1.811	14.554	-5.219	43.544	39.301	-9.550	1011.030	9141.120	-9.586
		1.812	14.554	-5.219	43.544	39.301	-9.550	1011.760	9180.830	-9.583
		1.813	14.554	-5.219	43.544	39.301	-9.550	1012.490	9220.620	-9.579
		1.814	14.554	-5.219	43.544	39.301	-9.550	1013.220	9260.350	-9.575
		1.815	14.554	-5.219	43.544	39.301	-9.550	1013.950	9300.040	-9.572
		1.816	14.554	-5.219	43.544	39.301	-9.550	1014.680	9339.780	-9.568
		1.817	14.554	-5.219	43.544	39.301	-9.550	1015.410	9379.480	-9.564
		1.818	14.554	-5.219	43.544	39.301	-9.550	1016.140	9419.140	-9.560
		1.819	14.554	-5.219	43.544	39.301	-9.550	1016.870	9458.760	-9.556
		1.820	14.554	-5.219	43.544	39.301	-9.550	1017.600	9498.350	-9.552
		1.821	14.554	-5.219	43.544	39.301	-9.550	1018.330	9537.910	-9.548
		1.822	14.554	-5.219	43.544	39.301	-9.550	1019.060	9577.440	-9.544
		1.823	14.554	-5.219	43.544	39.301	-9.550	1019.790	9616.940	-9.540
		1.824	14.554	-5.219	43.544	39.301	-9.550	1020.520	9656.410	-9.536
		1.825	14.554	-5.219	43.544	39.301	-9.550	1021.250	9695.860	-9.532
		1.826	14.554	-5.219	43.544	39.301	-9.550	1021.980	9735.280	-9.528
		1.827	14.554	-5.219	43.544	39.301	-9.550	1022.710	9774.680	-9.524
		1.828	14.554	-5.219	43.544	39.301	-9.550	1023.440	9814.050	-9.520
		1.829	14.554	-5.219	43.544	39.301	-9.550	1024.170	9853.390	-9.516
		1.830	14.554	-5.219	43.544	39.301	-9.550	1024.900	9892.700	-9.512
		1.831	14.554	-5.219	43.544	39.301	-9.550	1025.630	9931.990	-9.508
		1.832	14.554	-5.219	43.544	39.301	-9.550	1026.360	9971.260	-9.504
		1.833	14.554	-5.219	43.544	39.301	-9.550	1027.090	10010.500	-9.500
		1.834	14.554	-5.219	43.544	39.301	-9.550	1027.820	10049.710	-9.496
		1.835	14.554	-5.219	43.544	39.301	-9.550	1028.550	10088.900	-9.492
		1.836	14.554	-5.219	43.544	39.301	-9.550	1029.280	10128.070	-9.488
		1.837	14.554	-5.219	43.544	39.301	-9.550	1030.010	10167.220	-9.484
		1.838	14.554	-5.219	43.544	39.301	-9.550	1030.740	10206.350	-9.480
		1.839	14.554	-5.219	43.544	39.301	-9.550	1031.470	10245.460	-9.476
		1.840	14.554	-5.219	43.544	39.301	-9.550	1032.200	10284.550	-9.472
		1.841	14.554	-5.219	43.544	39.301	-9.550	1032.930	10323.620	-9.468
		1.842	14.554	-5.219	43.544	39.301	-9.550	1033.660	10362.670	-9.464
		1.843	14.554	-5.219	43.544	39.301	-9.550	1034.390	10401.700	-9.460
		1.844	14.554	-5.219	43.544	39.301	-9.550	1035.120	10440.710	-9.456
		1.845	14.554	-5.219	43.544	39.301	-9.550	1035.850	10479.700	-9.452
		1.846	14.554	-5.219	43.544	39.301	-9.550	1036.580	10518.670	-9.448
		1.847	14.554	-5.219	43.544	39.301	-9.550	1037.310	10557.620	-9.444
		1.848	14.554	-5.219	43.544	39.301	-9.550	1038.040	10596.550	-9.440
		1.849	14.554	-5.219	43.544	39.301	-9.550	1038.770	10635.460	-9.436
		1.850	14.554	-5.219	43.544	39.301	-9.550	1039.500	10674.350	-9.432
		1.851	14.554	-5.219	43.544	39.301	-9.550	1040.230	10713.220	-9.428
		1.852	14.554	-5.219	43.544	39.301	-9.550	1040.960	10752.070	-9.424
		1.853	14.554	-5.219	43.544	39.301	-9.550	1041.690	10790.900	-9.420
		1.854	14.554	-5.219	43.544	39.301	-9.550	1042.420	10829.710	-9.416
		1.855	14.554	-5.219	43.544	39.301	-9.550	1043.150	10868.500	-9.412
		1.856	14.554	-5.219	43.544	39.301	-9.550	1043.880	10907.270	-9.408
		1.857	14.554	-5.219	43.544	39.301	-9.550	1044.610	10946.020	-9.404
		1.858	14.554	-5.219	43.544	39.301	-9.550	1045.340	10984.750	-9.400
		1.859	14.554	-5.219	43.544	39.301	-9.550	1046.070	11023.460	-9.396
		1.860	14.554	-5.219	43.544	39.301	-9.550	1046.800	11062.150	-9.392
		1.861	14.554	-5.219	43.544	39.301	-9.550	1047.530	11100.820	-9.388
		1.862	14.554	-5.219	43.544	39.301	-9.550	1048.260	11139.470	-9.384
		1.863	14.554	-5.219	43.544	39.301	-9.550	1048.990	11178.100	-9.380
		1.864	14.554	-5.219	43.544	39.301	-9.550	1049.720	11216.710	-9.376
		1.865	14.554	-5.219	43.544	39.301	-9.550	1050.450	11255.300	-9.372
		1.866	14.554	-5.219	43.544	39.301	-9.550	1051.180	11293.870	-9.368
		1.867	14.554	-5.219	43.544	39.301	-9.550	1051.910	11332.420	-9.364
		1.868	14.554	-5.219	43.544	39.301	-9.550	1052.640	11370.950	-9.360
		1.869	14.554	-5.219	43.544	39.301	-9.550	1053.370	11409.460	-9.356
		1.870	14.554	-5.219	43.544	39.301	-9.550	1054.100	11447.950	-9.352
		1.871	14.554	-5.219	43.544	39.301	-9.550	1054.830	11486.420	-9.348
		1.872	14.554	-5.219	43.544	39.301	-9.550	1055.560	11524.870	-9.344
		1.873	14.554	-5.219	43.544	39.301	-9.550	1056.290	11563.300	-9.340
		1.874	14.554	-5.219	43.544	39.301	-9.550	1057.020	11601.710	-9.336
		1.875	14.554	-5.219	43.544	39.301	-9.550	1057.750	11640.100	-9.332
		1.876	14.554	-5.219	43.544	39.301	-9.550	1058.480	11678.470	-9.328
		1.877	14.554	-5.219	43.544	39.301	-9.550	1059.210	11716.820	-9.324
		1.878	14.554	-5.219	43.544	39.301	-9.550	1059.940	11755.150	-9.320
		1.879	14.554	-5.219	43.544	39.301	-9.550	1060.670	11793.460	-9.316
		1.880	14.554	-5.219	43.544	39.301	-9.550	1061.400	11831.750	-9.312
		1.881	14.554	-5.219	43.544	39.301	-9.550	1062.130	11870.020	-9.308
		1.882	14.554	-5.219	43.544	39.301	-9.550	1062.860	11908.270	-9.304
		1.883	14.554	-5.219	43.544	39.301	-9.550	1063.590	11946.500	-9.300
		1.884	14.554	-5.219	43.544	39.301	-9.550	1064.320	11984.710	-9.296
		1.885	14.554	-5.219	43.544	39.301	-9.550	1065.050	12022.900	-9.292
		1.886	14.554	-5.219	43.544	39.301	-9.550	1065.780	12061.070	-9.288
		1.887	14.554	-5.219	43.544	39.301	-9.550	1066.510	12099.220	-9.284
		1.888	14.554	-5.219	43.544	39.301	-9.550	1067.240	12137.350	-9.280
		1.889	14.554	-5.219	43.544	39.301	-9.550	1067.970	12175.460	-9.276
		1.890	14.554	-5.219	43.544	39.301	-9.550	1068.700	12213.550	-9.272
		1.891	14.554	-5.219	43.544	39.301	-9.550	1069.430	12251.620	-9.268
		1.892	14.554	-5.219	43.544	39.301	-9.550	1070.160	12289.670	-9.264
		1.893	14.554	-5.219	43.544	39.301	-9.550	1070.890	12327.700	-9.260
		1.894	14.554	-5.219	43.544	39.301	-9.550	1071.620	12365.710	-9.256
		1.895	14.554	-5.219	43.544	39.301	-9.550	1072.350	12403.700	-9.252
		1.896	14.554	-5.219	43.544	39.301	-9.550	1073.080	12441.670	-9.248
		1.897	14.554	-5.219	43.544	39.301	-9.550	1073.810	12479.620	-9.244
		1.898	14.554	-5.219	43.544	39.301	-9.550	1074.540	12517.550	-9.240
		1.899	14.554	-5.219	43.544	39.301	-9.550	1075.270	12555.460	-9.236
		1.900	14.554	-5.219	43.544	39.301	-9.550	1076.000	12593.350	-9.232
		1.901	14.554	-5.219	43.544	39.301	-9.550	1076.730	12631.220	-9.228
		1.902	14.554	-5.219	43.544	39.301	-9.550	1077.460	12669.070	-9.224
		1.903	14.554	-5.219	43.544	39.301	-9.550	1078.190	12706.900	-9.220
		1.904	14.554	-5.219	43.544	39.301	-9.550	1078.920	12744.710	-9.216
		1.905	14.554	-5.219	43.544	39.301	-9.550	1079.650	12782.500	-9.212
		1.906	14.554	-5.219	43.544	39.301	-9.550	1080.380	12820.270	-9.208
		1.907	14.554	-5.219	43.544	39.301	-9.550	1081.110	12858.020	-9.204
		1.908	14.554	-5.219	43.544	39.301	-9.550	1081.840	12895.750	-9.200
		1.909	14.554	-5.219	43.544	39.301	-9.550	1082.570	12933.460	-9.196
		1.910	14.554	-5.219	43.544	39.301	-9.550	1083.300	12971.150	-9.192
		1.911	14.554	-5.219	43.544	39.301	-9.550	1084.030	13008.820	-9.188
		1.912	14.554	-5.219	43.544	39.301	-9.550	1084.760	13046.470	-9.184
		1.913	14.554	-5.219	43.544	39.301	-9.550	1085.490	13084.100	-9.180
		1.914	14.554	-5.219	43.544	39.301	-9.550	1086.220	13121.710	-9.176
		1.915	14.554	-5.219	43.544	39.301	-9.550	1086.950	13159.300	-9.172
		1.916	14.554	-5.219	43.544	39.301	-9.550	1087.680	13196.870	-9.168
		1.917	14.554	-5.219	43.544	39.301	-9.550	1088.410		

[illegible]

Z	r	LTD LC	LTD HHC	%Error	CD LC	CD HHC	%Error	LD LC	LD HHC	%Error
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
364.05	0.007	13.832	14.577	-5.189	44.244	44.577	10.685	1615.40	14425.600	10.685
365.05	0.007	13.832	14.578	-5.190	44.244	44.578	10.683	16195.70	14446.500	10.683
366.05	0.007	13.832	14.578	-5.191	44.244	44.578	10.682	16239.90	14505.200	10.682
367.05	0.007	13.832	14.578	-5.191	44.244	44.578	10.681	16284.20	14544.900	10.681
		13.832	14.578	-5.192	44.244	44.578	10.679	16328.40	14584.600	10.679
		13.832	14.578	-5.193	44.244	44.578	10.678	16372.60	14624.300	10.678
		13.832	14.578	-5.194	44.244	44.578	10.677	16416.80	14664.000	10.677
		13.832	14.578	-5.195	44.244	44.578	10.676	16461.00	14703.700	10.676
		13.832	14.578	-5.196	44.244	44.578	10.675	16505.20	14743.400	10.675
		13.832	14.578	-5.197	44.244	44.578	10.674	16549.40	14783.100	10.674
		13.832	14.578	-5.198	44.244	44.578	10.673	16593.60	14822.800	10.673
		13.832	14.578	-5.199	44.244	44.578	10.672	16637.80	14862.500	10.672
		13.832	14.578	-5.200	44.244	44.578	10.671	16682.00	14902.200	10.671
		13.832	14.578	-5.201	44.244	44.578	10.670	16726.20	14941.900	10.670
		13.832	14.578	-5.202	44.244	44.578	10.669	16770.40	14981.600	10.669
		13.832	14.578	-5.203	44.244	44.578	10.668	16814.60	15021.300	10.668
		13.832	14.578	-5.204	44.244	44.578	10.667	16858.80	15061.000	10.667
		13.832	14.578	-5.205	44.244	44.578	10.666	16903.00	15100.700	10.666
		13.832	14.578	-5.206	44.244	44.578	10.665	16947.20	15140.400	10.665
		13.832	14.578	-5.207	44.244	44.578	10.664	16991.40	15180.100	10.664
		13.832	14.578	-5.208	44.244	44.578	10.663	17035.60	15219.800	10.663
		13.832	14.578	-5.209	44.244	44.578	10.662	17079.80	15259.500	10.662
		13.832	14.578	-5.210	44.244	44.578	10.661	17124.00	15299.200	10.661
		13.832	14.578	-5.211	44.244	44.578	10.660	17168.20	15338.900	10.660
		13.832	14.578	-5.212	44.244	44.578	10.659	17212.40	15378.600	10.659
		13.832	14.578	-5.213	44.244	44.578	10.658	17256.60	15418.300	10.658
		13.832	14.578	-5.214	44.244	44.578	10.657	17300.80	15458.000	10.657
		13.832	14.578	-5.215	44.244	44.578	10.656	17345.00	15497.700	10.656
		13.832	14.578	-5.216	44.244	44.578	10.655	17389.20	15537.400	10.655
		13.832	14.578	-5.217	44.244	44.578	10.654	17433.40	15577.100	10.654
		13.832	14.578	-5.218	44.244	44.578	10.653	17477.60	15616.800	10.653
		13.832	14.578	-5.219	44.244	44.578	10.652	17521.80	15656.500	10.652
		13.832	14.578	-5.220	44.244	44.578	10.651	17566.00	15696.200	10.651
		13.832	14.578	-5.221	44.244	44.578	10.650	17610.20	15735.900	10.650
		13.832	14.578	-5.222	44.244	44.578	10.649	17654.40	15775.600	10.649
		13.832	14.578	-5.223	44.244	44.578	10.648	17698.60	15815.300	10.648
		13.832	14.578	-5.224	44.244	44.578	10.647	17742.80	15855.000	10.647
		13.832	14.578	-5.225	44.244	44.578	10.646	17787.00	15894.700	10.646
		13.832	14.578	-5.226	44.244	44.578	10.645	17831.20	15934.400	10.645
		13.832	14.578	-5.227	44.244	44.578	10.644	17875.40	15974.100	10.644
		13.832	14.578	-5.228	44.244	44.578	10.643	17919.60	16013.800	10.643
		13.832	14.578	-5.229	44.244	44.578	10.642	17963.80	16053.500	10.642
		13.832	14.578	-5.230	44.244	44.578	10.641	18008.00	16093.200	10.641
		13.832	14.578	-5.231	44.244	44.578	10.640	18052.20	16132.900	10.640
		13.832	14.578	-5.232	44.244	44.578	10.639	18096.40	16172.600	10.639
		13.832	14.578	-5.233	44.244	44.578	10.638	18140.60	16212.300	10.638
		13.832	14.578	-5.234	44.244	44.578	10.637	18184.80	16252.000	10.637
		13.832	14.578	-5.235	44.244	44.578	10.636	18229.00	16291.700	10.636
		13.832	14.578	-5.236	44.244	44.578	10.635	18273.20	16331.400	10.635
		13.832	14.578	-5.237	44.244	44.578	10.634	18317.40	16371.100	10.634
		13.832	14.578	-5.238	44.244	44.578	10.633	18361.60	16410.800	10.633
		13.832	14.578	-5.239	44.244	44.578	10.632	18405.80	16450.500	10.632
		13.832	14.578	-5.240	44.244	44.578	10.631	18450.00	16490.200	10.631
		13.832	14.578	-5.241	44.244	44.578	10.630	18494.20	16529.900	10.630
		13.832	14.578	-5.242	44.244	44.578	10.629	18538.40	16569.600	10.629
		13.832	14.578	-5.243	44.244	44.578	10.628	18582.60	16609.300	10.628
		13.832	14.578	-5.244	44.244	44.578	10.627	18626.80	16649.000	10.627
		13.832	14.578	-5.245	44.244	44.578	10.626	18671.00	16688.700	10.626
		13.832	14.578	-5.246	44.244	44.578	10.625	18715.20	16728.400	10.625
		13.832	14.578	-5.247	44.244	44.578	10.624	18759.40	16768.100	10.624
		13.832	14.578	-5.248	44.244	44.578	10.623	18803.60	16807.800	10.623
		13.832	14.578	-5.249	44.244	44.578	10.622	18847.80	16847.500	10.622
		13.832	14.578	-5.250	44.244	44.578	10.621	18892.00	16887.200	10.621
		13.832	14.578	-5.251	44.244	44.578	10.620	18936.20	16926.900	10.620
		13.832	14.578	-5.252	44.244	44.578	10.619	18980.40	16966.600	10.619
		13.832	14.578	-5.253	44.244	44.578	10.618	19024.60	17006.300	10.618
		13.832	14.578	-5.254	44.244	44.578	10.617	19068.80	17046.000	10.617
		13.832	14.578	-5.255	44.244	44.578	10.616	19113.00	17085.700	10.616
		13.832	14.578	-5.256	44.244	44.578	10.615	19157.20	17125.400	10.615
		13.832	14.578	-5.257	44.244	44.578	10.614	19201.40	17165.100	10.614
		13.832	14.578	-5.258	44.244	44.578	10.613	19245.60	17204.800	10.613
		13.832	14.578	-5.259	44.244	44.578	10.612	19289.80	17244.500	10.612
		13.832	14.578	-5.260	44.244	44.578	10.611	19334.00	17284.200	10.611
		13.832	14.578	-5.261	44.244	44.578	10.610	19378.20	17323.900	10.610
		13.832	14.578	-5.262	44.244	44.578	10.609	19422.40	17363.600	10.609
		13.832	14.578	-5.263	44.244	44.578	10.608	19466.60	17403.300	10.608
		13.832	14.578	-5.264	44.244	44.578	10.607	19510.80	17443.000	10.607
		13.832	14.578	-5.265	44.244	44.578	10.606	19555.00	17482.700	10.606
		13.832	14.578	-5.266	44.244	44.578	10.605	19599.20	17522.400	10.605
		13.832	14.578	-5.267	44.244	44.578	10.604	19643.40	17562.100	10.604
		13.832	14.578	-5.268	44.244	44.578	10.603	19687.60	17601.800	10.603
		13.832	14.578	-5.269	44.244	44.578	10.602	19731.80	17641.500	10.602
		13.832	14.578	-5.270	44.244	44.578	10.601	19776.00	17681.200	10.601
		13.832	14.578	-5.271	44.244	44.578	10.600	19820.20	17720.900	10.600
		13.832	14.578	-5.272	44.244	44.578	10.599	19864.40	17760.600	10.599
		13.832	14.578	-5.273	44.244	44.578	10.598	19908.60	17800.300	10.598
		13.832	14.578	-5.274	44.244	44.578	10.597	19952.80	17840.000	10.597
		13.832	14.578	-5.275	44.244	44.578	10.596	19997.00	17879.700	10.596
		13.832	14.578	-5.276	44.244	44.578	10.595	20041.20	17919.400	10.595
		13.832	14.578	-5.277	44.244	44.578	10.594	20085.40	17959.100	10.594
		13.832	14.578	-5.278	44.244	44.578	10.593	20129.60	18000.000	10.593
		13.832	14.578	-5.279	44.244	44.578	10.592	20173.80	18040.000	10.592
		13.832	14.578	-5.280	44.244	44.578	10.591	20218.00	18080.000	10.591
		13.832	14.578	-5.281	44.244	44.578	10.590	20262.20	18120.000	10.590
		13.832	14.578	-5.282	44.244	44.578	10.589	20306.40	18160.000	10.589
		13.832	14.578	-5.283	44.244	44.578	10.588	20350.60	18200.000	10.588
		13.832	14.578	-5.284	44.244	44.578	10.587	20394.80	18240.000	10.587
		13.832	14.578	-5.285	44.244	44.578	10.586	20439.00	18280.000	10.586
		13.832	14.578	-5.286	44.244	44.578	10.585	20483.20	18320.000	10.585
		13.832	14.578	-5.287	44.244	44.578	10.584	20527.40	18360.000	10.584
		13.832	14.578	-5.288	44.244	44.578	10.583	20571.60	18400.000	10.583
		13.832	14.578	-5.289	44.244	44.578	10.582	20615.80	18440.000	10.582
		13.832	14.578	-5.290	44.244	44.578	10.581	20660.00	18480.000	10.581
		13.832	14.578	-5.291	44.244	44.578	10.580	20704.20	18520.000	10.580
		13.832	14.578	-5.292						

Z		LTD LC	LTD HHC	%Error	CD LC	CD HHC	%Error	LD LC	LD HHC	%Error
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		13 933	4 584	-5 430	44 440	39 551	11 002	19200 30	17087 700	11 003
		13 933	4 584	-5 431	44 440	39 551	11 002	19244 80	17127 600	11 001
		13 933	4 584	-5 431	44 440	39 552	11 002	19289 20	17167 200	11 001
		13 933	4 584	-5 432	44 440	39 552	11 000	19333 70	17207 000	11 000
		13 933	4 584	-5 432	44 440	39 552	10 998	19378 20	17246 800	10 998
		13 933	4 584	-5 433	44 440	39 553	10 995	19422 70	17286 600	10 997
		13 933	4 584	-5 434	44 440	39 554	10 995	19467 20	17326 400	10 997
178 05	0 998	13 933	4 584	-5 434	44 440	39 554	10 995	19511 70	17366 200	10 997
435 05	0 998	13 933	4 584	-5 435	44 440	39 554	10 995	19556 20	17406 000	10 996
		13 933	4 584	-5 435	44 440	39 554	10 995	19600 70	17445 800	10 996
		13 933	4 584	-5 436	44 440	39 555	10 995	19645 20	17485 600	10 996
		13 933	4 584	-5 436	44 440	39 555	10 995	19689 70	17525 400	10 996
		13 933	4 584	-5 437	44 440	39 556	10 995	19734 20	17565 200	10 996
		13 933	4 584	-5 437	44 440	39 556	10 995	19778 70	17605 000	10 996
		13 933	4 584	-5 438	44 440	39 557	10 995	19823 20	17644 800	10 996
		13 933	4 584	-5 438	44 440	39 557	10 995	19867 70	17684 600	10 996
		13 933	4 584	-5 439	44 440	39 558	10 995	19912 20	17724 400	10 996
		13 933	4 584	-5 439	44 440	39 558	10 995	19956 70	17764 200	10 996
		13 933	4 584	-5 440	44 440	39 559	10 995	20001 20	17804 000	10 996
		13 933	4 584	-5 440	44 440	39 559	10 995	20045 70	17843 800	10 996
		13 933	4 584	-5 441	44 440	39 560	10 995	20090 20	17883 600	10 996
		13 933	4 584	-5 441	44 440	39 560	10 995	20134 70	17923 400	10 996
		13 933	4 584	-5 442	44 440	39 561	10 995	20179 20	17963 200	10 996
		13 933	4 584	-5 442	44 440	39 561	10 995	20223 70	18003 000	10 996
		13 933	4 584	-5 443	44 440	39 562	10 995	20268 20	18042 800	10 996
		13 933	4 584	-5 443	44 440	39 562	10 995	20312 70	18082 600	10 996
		13 933	4 584	-5 444	44 440	39 563	10 995	20357 20	18122 400	10 996
		13 933	4 584	-5 444	44 440	39 563	10 995	20401 70	18162 200	10 996
		13 933	4 584	-5 445	44 440	39 564	10 995	20446 20	18202 000	10 996
		13 933	4 584	-5 445	44 440	39 564	10 995	20490 70	18241 800	10 996
		13 933	4 584	-5 446	44 440	39 565	10 995	20535 20	18281 600	10 996
		13 933	4 584	-5 446	44 440	39 565	10 995	20579 70	18321 400	10 996
		13 933	4 584	-5 447	44 440	39 566	10 995	20624 20	18361 200	10 996
		13 933	4 584	-5 447	44 440	39 566	10 995	20668 70	18401 000	10 996
		13 933	4 584	-5 448	44 440	39 567	10 995	20713 20	18440 800	10 996
		13 933	4 584	-5 448	44 440	39 567	10 995	20757 70	18480 600	10 996
		13 933	4 584	-5 449	44 440	39 568	10 995	20802 20	18520 400	10 996
		13 933	4 584	-5 449	44 440	39 568	10 995	20846 70	18560 200	10 996
		13 933	4 584	-5 450	44 440	39 569	10 995	20891 20	18600 000	10 996
		13 933	4 584	-5 450	44 440	39 569	10 995	20935 70	18639 800	10 996
		13 933	4 584	-5 451	44 440	39 570	10 995	20980 20	18679 600	10 996
		13 933	4 584	-5 451	44 440	39 570	10 995	21024 70	18719 400	10 996
		13 933	4 584	-5 452	44 440	39 571	10 995	21069 20	18759 200	10 996
		13 933	4 584	-5 452	44 440	39 571	10 995	21113 70	18799 000	10 996
		13 933	4 584	-5 453	44 440	39 572	10 995	21158 20	18838 800	10 996
		13 933	4 584	-5 453	44 440	39 572	10 995	21202 70	18878 600	10 996
		13 933	4 584	-5 454	44 440	39 573	10 995	21247 20	18918 400	10 996
		13 933	4 584	-5 454	44 440	39 573	10 995	21291 70	18958 200	10 996
		13 933	4 584	-5 455	44 440	39 574	10 995	21336 20	18998 000	10 996
		13 933	4 584	-5 455	44 440	39 574	10 995	21380 70	19037 800	10 996
		13 933	4 584	-5 456	44 440	39 575	10 995	21425 20	19077 600	10 996
		13 933	4 584	-5 456	44 440	39 575	10 995	21469 70	19117 400	10 996
		13 933	4 584	-5 457	44 440	39 576	10 995	21514 20	19157 200	10 996
		13 933	4 584	-5 457	44 440	39 576	10 995	21558 70	19197 000	10 996
		13 933	4 584	-5 458	44 440	39 577	10 995	21603 20	19236 800	10 996
		13 933	4 584	-5 458	44 440	39 577	10 995	21647 70	19276 600	10 996
		13 933	4 584	-5 459	44 440	39 578	10 995	21692 20	19316 400	10 996
		13 933	4 584	-5 459	44 440	39 578	10 995	21736 70	19356 200	10 996
		13 933	4 584	-5 460	44 440	39 579	10 995	21781 20	19396 000	10 996
		13 933	4 584	-5 460	44 440	39 579	10 995	21825 70	19435 800	10 996
		13 933	4 584	-5 461	44 440	39 580	10 995	21870 20	19475 600	10 996
		13 933	4 584	-5 461	44 440	39 580	10 995	21914 70	19515 400	10 996
		13 933	4 584	-5 462	44 440	39 581	10 995	21959 20	19555 200	10 996
		13 933	4 584	-5 462	44 440	39 581	10 995	22003 70	19595 000	10 996
		13 933	4 584	-5 463	44 440	39 582	10 995	22048 20	19634 800	10 996
		13 933	4 584	-5 463	44 440	39 582	10 995	22092 70	19674 600	10 996
		13 933	4 584	-5 464	44 440	39 583	10 995	22137 20	19714 400	10 996
		13 933	4 584	-5 464	44 440	39 583	10 995	22181 70	19754 200	10 996
		13 933	4 584	-5 465	44 440	39 584	10 995	22226 20	19794 000	10 996
		13 933	4 584	-5 465	44 440	39 584	10 995	22270 70	19833 800	10 996
		13 933	4 584	-5 466	44 440	39 585	10 995	22315 20	19873 600	10 996
		13 933	4 584	-5 466	44 440	39 585	10 995	22359 70	19913 400	10 996
		13 933	4 584	-5 467	44 440	39 586	10 995	22404 20	19953 200	10 996
		13 933	4 584	-5 467	44 440	39 586	10 995	22448 70	19993 000	10 996
		13 933	4 584	-5 468	44 440	39 587	10 995	22493 20	20032 800	10 996
		13 933	4 584	-5 468	44 440	39 587	10 995	22537 70	20072 600	10 996
		13 933	4 584	-5 469	44 440	39 588	10 995	22582 20	20112 400	10 996
		13 933	4 584	-5 469	44 440	39 588	10 995	22626 70	20152 200	10 996
		13 933	4 584	-5 470	44 440	39 589	10 995	22671 20	20192 000	10 996
		13 933	4 584	-5 470	44 440	39 589	10 995	22715 70	20231 800	10 996
		13 933	4 584	-5 471	44 440	39 590	10 995	22760 20	20271 600	10 996
		13 933	4 584	-5 471	44 440	39 590	10 995	22804 70	20311 400	10 996
		13 933	4 584	-5 472	44 440	39 591	10 995	22849 20	20351 200	10 996
		13 933	4 584	-5 472	44 440	39 591	10 995	22893 70	20391 000	10 996
		13 933	4 584	-5 473	44 440	39 592	10 995	22938 20	20430 800	10 996
		13 933	4 584	-5 473	44 440	39 592	10 995	22982 70	20470 600	10 996
		13 933	4 584	-5 474	44 440	39 593	10 995	23027 20	20510 400	10 996
		13 933	4 584	-5 474	44 440	39 593	10 995	23071 70	20550 200	10 996
		13 933	4 584	-5 475	44 440	39 594	10 995	23116 20	20590 000	10 996
		13 933	4 584	-5 475	44 440	39 594	10 995	23160 70	20629 800	10 996
		13 933	4 584	-5 476	44 440	39 595	10 995	23205 20	20669 600	10 996
		13 933	4 584	-5 476	44 440	39 595	10 995	23249 70	20709 400	10 996
		13 933	4 584	-5 477	44 440	39 596	10 995	23294 20	20749 200	10 996
		13 933	4 584	-5 477	44 440	39 596	10 995	23338 70	20789 000	10 996
		13 933	4 584	-5 478	44 440	39 597	10 995	23383 20	20828 800	10 996
		13 933	4 584	-5 478	44 440	39 597	10 995	23427 70	20868 600	10 996
		13 933	4 584	-5 479	44 440	39 598	10 995	23472 20	20908 400	10 996
		13 933	4 584	-5 479	44 440	39 598	10 995	23516 70	20948 200	10 996
		13 933	4 584	-5 480	44 440	39 599	10 995	23561 20	20988 000	10 996
		13 933	4 584	-5 480	44 440	39 599	10 995	23605 70	21027 800	10 996
		13 933	4 584	-5 481	44 440	39 600	10 995	23650 20	21067 600	10 996
		13 933	4 584	-5 481	44 440	39 600	10 995	23694 70	21107 400	10 996
		13 933	4 584	-5 482	44 440	39 601	10 995	23739 20	21147 200	10 996
		13 933	4 584	-5 482	44 440	39 601	10 995	23783 70	21187 000	10 996
		13 933	4 584	-5 483	44 440	39 602	10 995	23828 20	21226 800	10 996
		13 933	4 584	-5 483	44 440	39				

[illegible]

[illegible]

Z	$z/(1+z)$	LTD LC	LTD HHC	%Error	CD LC	CD HHC	%Error	LD LC	LD HHC	%Error
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
0.12 05	0.096	13.833	14.594	-5.502	44.823	39.609	11.633	28175.30	25074.600	11.632
0.14 05	0.108	13.833	14.594	-5.503	44.823	39.609	11.632	28464.00	25157.600	11.633
0.16 05	0.120	13.833	14.594	-5.503	44.823	39.610	11.632	28752.80	25193.800	11.633
0.18 05	0.132	13.833	14.595	-5.503	44.823	39.610	11.631	29041.60	25272.600	11.632
0.20 05	0.144	13.833	14.595	-5.504	44.823	39.610	11.631	29330.40	25313.200	11.632
0.22 05	0.156	13.833	14.595	-5.504	44.823	39.610	11.631	29619.20	25353.800	11.632
0.24 05	0.168	13.833	14.595	-5.504	44.823	39.610	11.631	29908.00	25394.400	11.632
0.26 05	0.180	13.833	14.595	-5.504	44.823	39.610	11.631	30196.80	25435.000	11.632
0.28 05	0.192	13.833	14.595	-5.504	44.823	39.610	11.631	30485.60	25475.600	11.632
0.30 05	0.204	13.833	14.595	-5.504	44.823	39.610	11.631	30774.40	25516.200	11.632
0.32 05	0.216	13.833	14.595	-5.504	44.823	39.610	11.631	31063.20	25556.800	11.632
0.34 05	0.228	13.833	14.595	-5.504	44.823	39.610	11.631	31352.00	25597.400	11.632
0.36 05	0.240	13.833	14.595	-5.504	44.823	39.610	11.631	31640.80	25638.000	11.632
0.38 05	0.252	13.833	14.595	-5.504	44.823	39.610	11.631	31929.60	25678.600	11.632
0.40 05	0.264	13.833	14.595	-5.504	44.823	39.610	11.631	32218.40	25719.200	11.632
0.42 05	0.276	13.833	14.595	-5.504	44.823	39.610	11.631	32507.20	25759.800	11.632
0.44 05	0.288	13.833	14.595	-5.504	44.823	39.610	11.631	32796.00	25800.400	11.632
0.46 05	0.300	13.833	14.595	-5.504	44.823	39.610	11.631	33084.80	25841.000	11.632
0.48 05	0.312	13.833	14.595	-5.504	44.823	39.610	11.631	33373.60	25881.600	11.632
0.50 05	0.324	13.833	14.595	-5.504	44.823	39.610	11.631	33662.40	25922.200	11.632
0.52 05	0.336	13.833	14.595	-5.504	44.823	39.610	11.631	33951.20	25962.800	11.632
0.54 05	0.348	13.833	14.595	-5.504	44.823	39.610	11.631	34240.00	26003.400	11.632
0.56 05	0.360	13.833	14.595	-5.504	44.823	39.610	11.631	34528.80	26044.000	11.632
0.58 05	0.372	13.833	14.595	-5.504	44.823	39.610	11.631	34817.60	26084.600	11.632
0.60 05	0.384	13.833	14.595	-5.504	44.823	39.610	11.631	35106.40	26125.200	11.632
0.62 05	0.396	13.833	14.595	-5.504	44.823	39.610	11.631	35395.20	26165.800	11.632
0.64 05	0.408	13.833	14.595	-5.504	44.823	39.610	11.631	35684.00	26206.400	11.632
0.66 05	0.420	13.833	14.595	-5.504	44.823	39.610	11.631	35972.80	26247.000	11.632
0.68 05	0.432	13.833	14.595	-5.504	44.823	39.610	11.631	36261.60	26287.600	11.632
0.70 05	0.444	13.833	14.595	-5.504	44.823	39.610	11.631	36550.40	26328.200	11.632
0.72 05	0.456	13.833	14.595	-5.504	44.823	39.610	11.631	36839.20	26368.800	11.632
0.74 05	0.468	13.833	14.595	-5.504	44.823	39.610	11.631	37128.00	26409.400	11.632
0.76 05	0.480	13.833	14.595	-5.504	44.823	39.610	11.631	37416.80	26450.000	11.632
0.78 05	0.492	13.833	14.595	-5.504	44.823	39.610	11.631	37705.60	26490.600	11.632
0.80 05	0.504	13.833	14.595	-5.504	44.823	39.610	11.631	37994.40	26531.200	11.632
0.82 05	0.516	13.833	14.595	-5.504	44.823	39.610	11.631	38283.20	26571.800	11.632
0.84 05	0.528	13.833	14.595	-5.504	44.823	39.610	11.631	38572.00	26612.400	11.632
0.86 05	0.540	13.833	14.595	-5.504	44.823	39.610	11.631	38860.80	26653.000	11.632
0.88 05	0.552	13.833	14.595	-5.504	44.823	39.610	11.631	39149.60	26693.600	11.632
0.90 05	0.564	13.833	14.595	-5.504	44.823	39.610	11.631	39438.40	26734.200	11.632
0.92 05	0.576	13.833	14.595	-5.504	44.823	39.610	11.631	39727.20	26774.800	11.632
0.94 05	0.588	13.833	14.595	-5.504	44.823	39.610	11.631	40016.00	26815.400	11.632
0.96 05	0.600	13.833	14.595	-5.504	44.823	39.610	11.631	40304.80	26856.000	11.632
0.98 05	0.612	13.833	14.595	-5.504	44.823	39.610	11.631	40593.60	26896.600	11.632
1.00 05	0.624	13.833	14.595	-5.504	44.823	39.610	11.631	40882.40	26937.200	11.632
1.02 05	0.636	13.833	14.595	-5.504	44.823	39.610	11.631	41171.20	26977.800	11.632
1.04 05	0.648	13.833	14.595	-5.504	44.823	39.610	11.631	41460.00	27018.400	11.632
1.06 05	0.660	13.833	14.595	-5.504	44.823	39.610	11.631	41748.80	27059.000	11.632
1.08 05	0.672	13.833	14.595	-5.504	44.823	39.610	11.631	42037.60	27100.000	11.632
1.10 05	0.684	13.833	14.595	-5.504	44.823	39.610	11.631	42326.40	27140.600	11.632
1.12 05	0.696	13.833	14.595	-5.504	44.823	39.610	11.631	42615.20	27181.200	11.632
1.14 05	0.708	13.833	14.595	-5.504	44.823	39.610	11.631	42904.00	27221.800	11.632
1.16 05	0.720	13.833	14.595	-5.504	44.823	39.610	11.631	43192.80	27262.400	11.632
1.18 05	0.732	13.833	14.595	-5.504	44.823	39.610	11.631	43481.60	27303.000	11.632
1.20 05	0.744	13.833	14.595	-5.504	44.823	39.610	11.631	43770.40	27343.600	11.632
1.22 05	0.756	13.833	14.595	-5.504	44.823	39.610	11.631	44059.20	27384.200	11.632
1.24 05	0.768	13.833	14.595	-5.504	44.823	39.610	11.631	44348.00	27424.800	11.632
1.26 05	0.780	13.833	14.595	-5.504	44.823	39.610	11.631	44636.80	27465.400	11.632
1.28 05	0.792	13.833	14.595	-5.504	44.823	39.610	11.631	44925.60	27506.000	11.632
1.30 05	0.804	13.833	14.595	-5.504	44.823	39.610	11.631	45214.40	27546.600	11.632
1.32 05	0.816	13.833	14.595	-5.504	44.823	39.610	11.631	45503.20	27587.200	11.632
1.34 05	0.828	13.833	14.595	-5.504	44.823	39.610	11.631	45792.00	27627.800	11.632
1.36 05	0.840	13.833	14.595	-5.504	44.823	39.610	11.631	46080.80	27668.400	11.632
1.38 05	0.852	13.833	14.595	-5.504	44.823	39.610	11.631	46369.60	27709.000	11.632
1.40 05	0.864	13.833	14.595	-5.504	44.823	39.610	11.631	46658.40	27749.600	11.632
1.42 05	0.876	13.833	14.595	-5.504	44.823	39.610	11.631	46947.20	27790.200	11.632
1.44 05	0.888	13.833	14.595	-5.504	44.823	39.610	11.631	47236.00	27830.800	11.632
1.46 05	0.900	13.833	14.595	-5.504	44.823	39.610	11.631	47524.80	27871.400	11.632
1.48 05	0.912	13.833	14.595	-5.504	44.823	39.610	11.631	47813.60	27912.000	11.632
1.50 05	0.924	13.833	14.595	-5.504	44.823	39.610	11.631	48102.40	27952.600	11.632
1.52 05	0.936	13.833	14.595	-5.504	44.823	39.610	11.631	48391.20	27993.200	11.632
1.54 05	0.948	13.833	14.595	-5.504	44.823	39.610	11.631	48680.00	28033.800	11.632
1.56 05	0.960	13.833	14.595	-5.504	44.823	39.610	11.631	48968.80	28074.400	11.632
1.58 05	0.972	13.833	14.595	-5.504	44.823	39.610	11.631	49257.60	28115.000	11.632
1.60 05	0.984	13.833	14.595	-5.504	44.823	39.610	11.631	49546.40	28155.600	11.632
1.62 05	0.996	13.833	14.595	-5.504	44.823	39.610	11.631	49835.20	28196.200	11.632
1.64 05	1.008	13.833	14.595	-5.504	44.823	39.610	11.631	50124.00	28236.800	11.632
1.66 05	1.020	13.833	14.595	-5.504	44.823	39.610	11.631	50412.80	28277.400	11.632
1.68 05	1.032	13.833	14.595	-5.504	44.823	39.610	11.631	50701.60	28318.000	11.632
1.70 05	1.044	13.833	14.595	-5.504	44.823	39.610	11.631	50990.40	28358.600	11.632
1.72 05	1.056	13.833	14.595	-5.504	44.823	39.610	11.631	51279.20	28399.200	11.632
1.74 05	1.068	13.833	14.595	-5.504	44.823	39.610	11.631	51568.00	28439.800	11.632
1.76 05	1.080	13.833	14.595	-5.504	44.823	39.610	11.631	51856.80	28480.400	11.632
1.78 05	1.092	13.833	14.595	-5.504	44.823	39.610	11.631	52145.60	28521.000	11.632
1.80 05	1.104	13.833	14.595	-5.504	44.823	39.610	11.631	52434.40	28561.600	11.632
1.82 05	1.116	13.833	14.595	-5.504	44.823	39.610	11.631	52723.20	28602.200	11.632
1.84 05	1.128	13.833	14.595	-5.504	44.823	39.610	11.631	53012.00	28642.800	11.632
1.86 05	1.140	13.833	14.595	-5.504	44.823	39.610	11.631	53300.80	28683.400	11.632
1.88 05	1.152	13.833	14.595	-5.504	44.823	39.610	11.631	53589.60	28724.000	11.632
1.90 05	1.164	13.833	14.595	-5.504	44.823	39.610	11.631	53878.40	28764.600	11.632
1.92 05	1.176	13.833	14.595	-5.504	44.823	39.610	11.631	54167.20	28805.200	11.632
1.94 05	1.188	13.833	14.595	-5.504	44.823	39.610	11.631	54456.00	28845.800	11.632
1.96 05	1.200	13.833	14.595	-5.504	44.823	39.610	11.631	54744		

[illegible]

[illegible]

[illegible]

[illegible]

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
		13 811	13 811	5 556	4 5	30 53	12 298	43768 70	38385 200	2 5 0
		13 812	13 812	5 556	45 5	31 52	12 298	43811 00	38425 200	2 5 0
		13 813	13 813	5 556	45 2 3	31 52	12 298	43859 10	38471 50	2 5 0
		13 814	13 814	5 556	45 5	31 53	12 298	43907 20	38528 00	2 5 0
		13 815	13 815	5 556	45 2 3	31 53	12 298	43955 30	38584 50	2 5 0
		13 816	13 816	5 557	45 213	31 53	12 298	44003 40	38641 00	2 5 0
		13 817	13 817	5 557	45 213	31 53	12 298	44051 50	38697 50	2 5 0
		13 818	13 818	5 557	45 213	31 53	12 298	44099 60	38754 00	2 5 0
		13 819	13 819	5 557	45 2 3	31 53	12 298	44147 70	38810 50	2 5 0
		13 820	13 820	5 557	45 2 3	31 53	12 298	44195 80	38867 00	2 5 0
		13 821	13 821	5 558	45 213	31 53	12 298	44243 90	38923 50	2 5 0
		13 822	13 822	5 558	45 2 3	31 53	12 298	44292 00	38980 00	2 5 0
		13 823	13 823	5 558	45 2 3	31 53	12 298	44340 10	39036 50	2 5 0
		13 824	13 824	5 558	45 2 3	31 53	12 298	44388 20	39093 00	2 5 0
		13 825	13 825	5 558	45 2 3	31 53	12 298	44436 30	39149 50	2 5 0
		13 826	13 826	5 558	45 2 3	31 53	12 298	44484 40	39206 00	2 5 0
		13 827	13 827	5 558	45 2 3	31 53	12 298	44532 50	39262 50	2 5 0
		13 828	13 828	5 558	45 2 3	31 53	12 298	44580 60	39319 00	2 5 0
		13 829	13 829	5 558	45 2 3	31 53	12 298	44628 70	39375 50	2 5 0
		13 830	13 830	5 558	45 2 3	31 53	12 298	44676 80	39432 00	2 5 0
		13 831	13 831	5 558	45 2 3	31 53	12 298	44724 90	39488 50	2 5 0
		13 832	13 832	5 558	45 2 3	31 53	12 298	44773 00	39545 00	2 5 0
		13 833	13 833	5 558	45 2 3	31 53	12 298	44821 10	39601 50	2 5 0
		13 834	13 834	5 558	45 2 3	31 53	12 298	44869 20	39658 00	2 5 0
		13 835	13 835	5 558	45 2 3	31 53	12 298	44917 30	39714 50	2 5 0
		13 836	13 836	5 558	45 2 3	31 53	12 298	44965 40	39771 00	2 5 0
		13 837	13 837	5 558	45 2 3	31 53	12 298	45013 50	39827 50	2 5 0
		13 838	13 838	5 558	45 2 3	31 53	12 298	45061 60	39884 00	2 5 0
		13 839	13 839	5 558	45 2 3	31 53	12 298	45109 70	39940 50	2 5 0
		13 840	13 840	5 558	45 2 3	31 53	12 298	45157 80	40000 00	2 5 0
		13 841	13 841	5 558	45 2 3	31 53	12 298	45205 90	40056 50	2 5 0
		13 842	13 842	5 558	45 2 3	31 53	12 298	45254 00	40113 00	2 5 0
		13 843	13 843	5 558	45 2 3	31 53	12 298	45302 10	40169 50	2 5 0
		13 844	13 844	5 558	45 2 3	31 53	12 298	45350 20	40226 00	2 5 0
		13 845	13 845	5 558	45 2 3	31 53	12 298	45398 30	40282 50	2 5 0
		13 846	13 846	5 558	45 2 3	31 53	12 298	45446 40	40339 00	2 5 0
		13 847	13 847	5 558	45 2 3	31 53	12 298	45494 50	40395 50	2 5 0
		13 848	13 848	5 558	45 2 3	31 53	12 298	45542 60	40452 00	2 5 0
		13 849	13 849	5 558	45 2 3	31 53	12 298	45590 70	40508 50	2 5 0
		13 850	13 850	5 558	45 2 3	31 53	12 298	45638 80	40565 00	2 5 0
		13 851	13 851	5 558	45 2 3	31 53	12 298	45686 90	40621 50	2 5 0
		13 852	13 852	5 558	45 2 3	31 53	12 298	45735 00	40678 00	2 5 0
		13 853	13 853	5 558	45 2 3	31 53	12 298	45783 10	40734 50	2 5 0
		13 854	13 854	5 558	45 2 3	31 53	12 298	45831 20	40791 00	2 5 0
		13 855	13 855	5 558	45 2 3	31 53	12 298	45879 30	40847 50	2 5 0
		13 856	13 856	5 558	45 2 3	31 53	12 298	45927 40	40904 00	2 5 0
		13 857	13 857	5 558	45 2 3	31 53	12 298	45975 50	40960 50	2 5 0
		13 858	13 858	5 558	45 2 3	31 53	12 298	46023 60	41017 00	2 5 0
		13 859	13 859	5 558	45 2 3	31 53	12 298	46071 70	41073 50	2 5 0
		13 860	13 860	5 558	45 2 3	31 53	12 298	46119 80	41130 00	2 5 0
		13 861	13 861	5 558	45 2 3	31 53	12 298	46167 90	41186 50	2 5 0
		13 862	13 862	5 558	45 2 3	31 53	12 298	46216 00	41243 00	2 5 0
		13 863	13 863	5 558	45 2 3	31 53	12 298	46264 10	41299 50	2 5 0
		13 864	13 864	5 558	45 2 3	31 53	12 298	46312 20	41356 00	2 5 0
		13 865	13 865	5 558	45 2 3	31 53	12 298	46360 30	41412 50	2 5 0
		13 866	13 866	5 558	45 2 3	31 53	12 298	46408 40	41469 00	2 5 0
		13 867	13 867	5 558	45 2 3	31 53	12 298	46456 50	41525 50	2 5 0
		13 868	13 868	5 558	45 2 3	31 53	12 298	46504 60	41582 00	2 5 0
		13 869	13 869	5 558	45 2 3	31 53	12 298	46552 70	41638 50	2 5 0
		13 870	13 870	5 558	45 2 3	31 53	12 298	46600 80	41695 00	2 5 0
		13 871	13 871	5 558	45 2 3	31 53	12 298	46648 90	41751 50	2 5 0
		13 872	13 872	5 558	45 2 3	31 53	12 298	46697 00	41808 00	2 5 0
		13 873	13 873	5 558	45 2 3	31 53	12 298	46745 10	41864 50	2 5 0
		13 874	13 874	5 558	45 2 3	31 53	12 298	46793 20	41921 00	2 5 0
		13 875	13 875	5 558	45 2 3	31 53	12 298	46841 30	41977 50	2 5 0
		13 876	13 876	5 558	45 2 3	31 53	12 298	46889 40	42034 00	2 5 0
		13 877	13 877	5 558	45 2 3	31 53	12 298	46937 50	42090 50	2 5 0
		13 878	13 878	5 558	45 2 3	31 53	12 298	46985 60	42147 00	2 5 0
		13 879	13 879	5 558	45 2 3	31 53	12 298	47033 70	42203 50	2 5 0
		13 880	13 880	5 558	45 2 3	31 53	12 298	47081 80	42260 00	2 5 0
		13 881	13 881	5 558	45 2 3	31 53	12 298	47129 90	42316 50	2 5 0
		13 882	13 882	5 558	45 2 3	31 53	12 298	47178 00	42373 00	2 5 0
		13 883	13 883	5 558	45 2 3	31 53	12 298	47226 10	42429 50	2 5 0
		13 884	13 884	5 558	45 2 3	31 53	12 298	47274 20	42486 00	2 5 0
		13 885	13 885	5 558	45 2 3	31 53	12 298	47322 30	42542 50	2 5 0
		13 886	13 886	5 558	45 2 3	31 53	12 298	47370 40	42599 00	2 5 0
		13 887	13 887	5 558	45 2 3	31 53	12 298	47418 50	42655 50	2 5 0
		13 888	13 888	5 558	45 2 3	31 53	12 298	47466 60	42712 00	2 5 0
		13 889	13 889	5 558	45 2 3	31 53	12 298	47514 70	42768 50	2 5 0
		13 890	13 890	5 558	45 2 3	31 53	12 298	47562 80	42825 00	2 5 0
		13 891	13 891	5 558	45 2 3	31 53	12 298	47610 90	42881 50	2 5 0
		13 892	13 892	5 558	45 2 3	31 53	12 298	47659 00	42938 00	2 5 0
		13 893	13 893	5 558	45 2 3	31 53	12 298	47707 10	42994 50	2 5 0
		13 894	13 894	5 558	45 2 3	31 53	12 298	47755 20	43051 00	2 5 0
		13 895	13 895	5 558	45 2 3	31 53	12 298	47803 30	43107 50	2 5 0
		13 896	13 896	5 558	45 2 3	31 53	12 298	47851 40	43164 00	2 5 0
		13 897	13 897	5 558	45 2 3	31 53	12 298	47899 50	43220 50	2 5 0
		13 898	13 898	5 558	45 2 3	31 53	12 298	47947 60	43277 00	2 5 0
		13 899	13 899	5 558	45 2 3	31 53	12 298	47995 70	43333 50	2 5 0
		13 900	13 900	5 558	45 2 3	31 53	12 298	48043 80	43390 00	2 5 0
		13 901	13 901	5 558	45 2 3	31 53	12 298	48091 90	43446 50	2 5 0
		13 902	13 902	5 558	45 2 3	31 53	12 298	48140 00	43503 00	2 5 0
		13 903	13 903	5 558	45 2 3	31 53	12 298	48188 10	43559 50	2 5 0
		13 904	13 904	5 558	45 2 3	31 53	12 298	48236 20	43616 00	2 5 0
		13 905	13 905	5 558	45 2 3	31 53	12 298	48284 30	43672 50	2 5 0
		13 906	13 906	5 558	45 2 3	31 53	12 298	48332 40	43729 00	2 5 0
		13 907	13 907	5 558	45 2 3	31 53	12 298	48380 50	43785 50	2 5 0
		13 908	13 908	5 558	45 2 3	31 53	12 298	48428 60	43842 00	2 5 0
		13 909	13 909	5 558	45 2 3	31 53	12 298	48476 70	43898 50	2 5 0
		13 910	13 910	5 558	45 2 3	31 53	12 298	48524 80	43955 00	2 5 0
		13 911	13 911	5 558	45 2 3	31 53	12 298	48572 90	44011 50	2 5 0
		13 912	13 912	5 558	45 2 3	31 53	12 298	48621 00	44068 00	2 5 0
		13 913	13 913	5 558	45 2 3	31 53	12 298	48669 10	44124 50	2 5 0
		13 914	13 914	5 558	45 2 3	31 53	12 298	48717 20	44181 00	2 5 0
		13 915	13 915	5 558	45 2 3	31 53	12 298	48765 30	44237 50	2 5 0
		13 916	13 916	5 558	45 2 3	31 53	12 298	48813 40	44294 00	2 5 0
		13 917	13 917	5 558	45 2 3	31 53	12 298	48861 50	44350 50	2 5 0
		13 918	13 918	5 558	45 2 3	31 53	12 298	48909 60	44407 00	2 5 0
		13 919	13 919	5 558	45 2 3	31 53	12 298	48957 70	44463 50	2 5 0
		13 920	13 920	5 558	45 2 3	31 53	12 298	49005 80	44520 00	2 5 0

[illegible]

8. Conclusion

By modifying our recently proposed light speed expanding Hubble-Hawking universe, in this paper we are presenting a very simple model of light speed rotating universe with a possible halt. It is absolutely against to the current notion of accelerating universe and dark energy. In this context, we would like to appeal that, based on the rate of decrease in current and future cosmic temperature, our proposal can be verified. Proceeding further, so far, no single cosmological observation has shed light the direct existence of dark energy and no single observation has reported a direct measure of galactic receding speed and direct measure of galactic accelerating speed. Point to be noted is that, whether galaxy is receding or revolving about a center also is not clear. It's a general and commonly followed belief that galactic distance is a measure of galactic receding speed. It may be noted that, based on proposed red shift definition, Hubble's law can be considered as a representation of ending stage of cosmic expansion having light speed rotation.

We agree that, in this paper, we are not providing sufficient cosmological explanation for the reasons of current cosmic halt, but it may be noted that factors like initial high cosmic expansion speed, decelerating mode of cosmic expansion with increasing mass and decreasing temperature, current sub zero cosmic temperature of 2.7 K, very small value of the current Hubble parameter and observed very minor fluctuations in current cosmic temperature can be considered as favorable conditions for further analysis. Considering our proposed energy based definition of red shift, it seems compulsory to review the basics of Lambda cosmology. If one is willing to consider red shift as a measure of galactic distance, one can get a chance to study the observable universe in a new dimension accompanied by light speed rotation. As explained in section (5), equations (8) to (12) are having very strange origin and need a careful review at fundamental level. If it is an accidental coincidence, as the equations are strongly coupled with gravitational and cosmic physical constants, then one must think about the scope, applicability and validity of those equations in a different manner with reference to Dirac model of large numbers or quantum gravity or final unification. We are sure to say that, theory point of view, these equations are having good scientific background compared to dark energy like ambiguous entities. With a joint research associated with microscopic physics and cosmic physics, true nature of cosmic expansion can be understood. As there exists no strong experimental

evidence for the currently believed dark matter, until its detection, dark matter can be considered as a representation of super gravity of galactic baryon mass associated with its cut-off mass limit at (180 to 200) million solar masses.

Qualitatively and quantitatively, in a theoretical approach, compared to the historical arguments on cosmic rotation, our views seem to be more coherent, strongly connected with quantum gravity and are closer to observational findings. Hence, we sincerely appeal the science community to recommend our light speed rotating model of the Hubble-Hawking universe for further research.

Acknowledgements

In preparing this paper, author Seshavatharam is greatly inspired by Dr. Mohsen Lutephy and Dr. Dimitar Todorov Valev for their thought provoking concepts on quantum cosmology associated with no further expansion. Seshavatharam is indebted to Professors Shri M. Nagaphani Sarma, Chairman; Shri K.V. Krishna Murthy, founder Chairman, Institute of Scientific Research in Vedas (I-SERVE), Hyderabad, India; and Shri K.V.R.S. Murthy, former scientist ICT (CSIR), Govt. of India, Director, Research and Development, I-SERVE, for their valuable guidance and support in developing this subject. Authors are very much thankful to the anonymous reviewers for their valuable suggestions in improving the quality of the paper.

Appendix A: C++ program for estimating various galactic distances

```
#include <conio.h>

#include <iostream.h>

#define c 299792.458

int main(){

float z=0.05;

do{

    z = z +1;

float H0 = 66.893;

// Hubble constant (km/s/Mpc) - adjust according to taste

float OM = 0.32; // Omega(matter) - adjust according to taste

float OL = 0.68; // Omega(lambda) - adjust according to taste

float OR = 0.42/(H0*H0);

// Omega(radiation) - this is the usual textbook value

long i;

long n=10000; // Number of steps in the integral

float OK = 1-OM-OR-OL; // Omega(k) defined as 1-OM-OR-OL

float HD = 3.2616*c/H0/1000; // Hubble distance (billions of light years).
See section 2 of Hogg
```



```
float a, adot;          // Redshift "z", Scale Factor "a", and its derivative "adot"

float DC, DCC=0, DT, DTT=0, DA, DL, DM;

float age, size;        // The age and size of the universe

for(i=n; i>=1; i--) {   // This loop is the numerical integration

    a = (i-0.5)/n;      // Steadily decrease the scale factor

    // Comoving formula

    (See section 4 of Hogg, but I've added a radiation term too):

    adot = a*sqrt(OM*pow(1/a,3)+OK*pow(1/a,2)+OL+OR*pow(1/a,4));

    // Note that "a" is equivalent to 1/(1+z)

    DCC = DCC + 1/(a*adot)/n; // Running total of the comoving distance

    DTT = DTT + 1/adot/n;

    // Running total of the light travel time (see section 10 of Hogg)

    if (a>=1/(1+z)) {   // Collect DC and DT until the correct scale is reached

        DC = DCC;      // Comoving distance DC

        DT = DTT;      // Light travel time DT

    }

}

// Transverse comoving distance DM from section 5 of Hogg:

if (OK>0.0001) DM=(1/sqrt(OK))*sinh(sqrt(OK)*DC);
```

```
else if (OK<-0.0001) DM=(1/sqrt(fabs(OK)))*sin(sqrt(fabs(OK))*DC);
else DM=DC;

age = HD*DTT;           // Age of the universe (billions of years)
size = HD*DCC;          // Comoving radius of the observable universe
DC = HD*DC;             // Comoving distance
A = HD*DM/(1+z);        // Angular diameter distance (section 6 of Hogg)
DL = HD*DM*(1+z);       // Luminosity distance (section 7 of Hogg)
DT = HD*DT;             // Light travel distance

float dt,zn,cd,ld;

zn=(z/(z+1));           // Modified red shift
dt=zn*HD;               // Estimated light travel distance
cd=exp(zn)*dt;           // Estimated comoving distance
ld=cd/(1-zn);           // Estimated luminosity distance

cout<<z<<" "<<zn<<" "<<DT<<" "<<dt<<" "<<((DT-dt)/DT)*100<<" "<<DC<<" "<<cd<<" "<<((DC-cd)/DC)*100<<" "<<DL<<" "<<ld<<" "<<((DL-ld)/DL)*100<<endl;

} while (z<=1100.0);
}
```

References

- [1] Cosmin Andreia, Anna Ijjasb and Paul J. Steinhardt. Rapidly descending dark energy and the end of cosmic expansion. *Proceedings of the National Academy of Sciences*, 119(15) e2200539119, 2022.
- [2] Perlmutter S et al. Measurements of Ω and Λ from 42 High-Redshift Supernovae. *The Astrophysical Journal*, 517(2): 565, 1999.
- [3] Fulvio Melia (Arizona U. and Arizona U., Astron. Dept. - Steward Observ.). Fitting the Union2.1 SN Sample with the $R_h=ct$ Universe. *Astron.J.* 144, 110, 2012.
- [4] Nielsen J.T, Guffanti A, Sarkar S. Marginal Evidence for Cosmic Acceleration from Type Ia Supernovae. *Nature, Scientific Reports* 6(Oct): 35596, 2016.
- [5] Lisa Goh Wan Khee. Thesis: Modified Statistical Analysis of Type Ia Supernovae Data. Supervisor. Supervisor: Shao Chin Cindy Ng, 2018-2019, National University of Singapore, Singapore.
- [6] Saadeh Daniela et al. How Isotropic is the Universe? *Phys. Rev. Lett.* 117:13, 131302, 2016.
- [7] Birch P. Is the Universe rotating? *Nature.* 298, 451-454, 1982.
- [8] C. Sivaram, Kenath Arun. Primordial Rotation of the Universe, Hydrodynamics, Vortices and Angular Momenta of Celestial Objects. *The Open Astronomy Journal*, 5, 7-11, 2012.
- [9] Vladimir A Korotky, Eduard Masár Yuri N Obukhov. In the Quest for Cosmic Rotation. *Universe*, 6:14, 2020.
- [10] Gianluca Calcagni et al. Lectures on classical and quantum cosmology. *PoS (CORFU2021)* 317, 2022.
- [11] Lopez-Corredoira M. Tests and Problems of the Standard Model in Cosmology. *Foundations of Physics*, 47, 711-768, 2017.
- [12] Di Valentino, E., Melchiorri, A. & Silk, J. Planck. Planck evidence for a closed Universe and a possible crisis for cosmology. *Nat Astron.* 4, 196–203, 2020.
- [13] George Ellis, Julien Larena. The case for a closed universe, *Astronomy & Geophysics*, 61(1), 1.38–1.40, 2020.
- [14] Will Handley. Curvature tension: evidence for a closed universe. *Phys. Rev. D* 103, 041301, 2021.
- [15] Hubble E.P. A Relation between Distance and Radial Velocity among Extra-Galactic Nebulae. *Proceedings of the National Academy of Sciences of the United States of America*, 15, 168-173, 1929.

- [16] Kurt Godel. Rotating Universes in General Relativity Theory. Proceedings of the international Congress of Mathematicians in Cambridge, 1: 175-81, 1950.
- [17] Wang, P. et al. Possible observational evidence for cosmic filament spin. Nat. Astron. 5, 839–845, 2021.
- [18] Seshavatharam U.V.S. Physics of Rotating and Expanding Black Hole Universe. Progress in Physics. 2 (April), 7-14, 2010.
- [19] Tatum E.T, Seshavatharam U.V.S, Lakshminarayana S. The basics of flat space cosmology. International Journal of Astronomy and Astrophysics, 5,116-124, 2015.
- [20] Seshavatharam U.V.S, Tatum E.T, Lakshminarayana S. The Large Scale Universe as a Quasi Quantum White Hole. International Astronomy and Astrophysics Research Journal. 3(1):22–42, 2021.
- [21] Seshavatharam U.V.S, Lakshminarayana S. Light speed expanding white hole universe having a red shift of $[z/(1+z)]$. World Scientific News, 162, 87-101, 2021.
- [22] Seshavatharam U.V.S, Lakshminarayana S. On the role of cosmic mass in understanding the relationships among galactic dark matter, visible matter and flat rotation speeds. NRIAG Journal of Astronomy and Geophysics. 10(1),1-15, 2021.
- [23] Seshavatharam U.V.S, Lakshminarayana S. Concepts and results of a Practical Model of Quantum Cosmology: Light Speed Expanding Black Hole Cosmology. Mapana Journal of Sciences. 21(2), 2022.
- [24] Seshavatharam U.V.S, Lakshminarayana S. Unified Quantum Gravity Pertaining to Nuclear and Cosmic Physics. Quantum Physics Letters. 11(2),23-30, 2022.
- [25] Seshavatharam U. V. S, Lakshminarayana S. Weak Interaction Dependent Super Gravity of Galactic Baryon Mass. Journal of Asian Scientific Research, 12(3), 146–155, 2022.

- [26] Seshavatharam U. V. S, Lakshminarayana S. Light Speed Expanding Hubble-Hawking Universe. Preprints 2022, 2022090279. <https://doi.org/10.20944/preprints202209.0279.v3>.
- [27] Seshavatharam U. V. S, Lakshminarayana S. A rotating model of light speed expanding Hubble-Hawking universe, in Proceedings of the 2nd Electronic Conference on Universe, 16 February–2 March 2023, MDPI: Basel, Switzerland, doi:10.3390/ECU2023-14065
- [28] Seshavatharam U. V. S, Lakshminarayana S. An open review on light speed expanding Hubble-Hawking universe.11(2): 322, 2023. (45 pages)
- [29] Hawking S. Black hole explosions? Nature 248, 30-31, 1974.
- [30] Planck Collaboration: Planck 2015 Results. XIII. Cosmological Parameters.
- [31] Jos'e Luis Berna et al. Robustness of baryon acoustic oscillation constraints for early-Universe modifications to Λ CDM. Phys. Rev. D 102, 123515, 2020.
- [32] David Hogg. Distance Measures in Cosmology. arXiv:astro-ph/9905116, 2000.
- [33] Pacetti, S., Tomasi-Gustafsson, E. The origin of the proton radius puzzle. Eur. Phys. J. A 57, 72, 2021.
- [34] Milgrom M. A Modification of the Newtonian Dynamics as a Possible Alternative to the Hidden Mass Hypothesis. The Astrophysical Journal , 270, 365-370, 1983.
- [35] Banik I. and Zhao H. From Galactic Bars to the Hubble Tension: Weighing Up the Astrophysical Evidence for Milgromian Gravity. Symmetry, 14, 1331, 2022.
- [36] Brownstein J. R. and Moffat J. W. Galaxy Rotation Curves Without Non-Baryonic Dark Matter. The Astrophysical Journal , 636, 721-741, 2006.
- [37] Sivaram, C., Arun, K. & Rebecca, L. MOND, MONG, MORG as alternatives to dark matter and dark energy and consequences for cosmic structures. J. Astrophys. Astron. 41, 4, 2020
- [38] Kyu-Hyun Chae et al. Testing the Strong Equivalence Principle: Detection of the External Field Effect in Rotationally Supported Galaxies. The Astrophysical Journal, 904(1), 2020, 20(pp).
- [39] D. W. Sciama. On the Origin of Inertia. Monthly Notices of the Royal Astronomical Society, 13(1), 34-42, 1953.

- [40] Shen Z et al. A Tip of the Red Giant Branch Distance of 22.1 ± 1.2 Mpc to the Dark Matter Deficient Galaxy NGC 1052–DF2 from 40 Orbits of Hubble Space Telescope Imaging. *The Astrophysical Journal Letters*. 914(1):L12, 2021.
- [41] Ogle, P.M., et al. A Break in Spiral Galaxy Scaling Relations at the Upper Limit of Galaxy Mass. *The Astrophysical Journal Letters* , 884, L11, 2019.
- [42] Gamow G. Rotating Universe? *Nature*. 158, 549, 1946.
- [43] E.T. Whittaker. Spin in the universe, *Yearbook of Roy. Soc. Edinburgh*, (1945) 5.
- [44] Hawking S. On the rotation of the Universe. *Monthly Notices of the Royal Astronomical Society*, 142, 129-141, 1969.
- [45] Godlowski, W. Global and Local Effects of Rotation: Observational Aspects. *International Journal of Modern Physics D*. 20, 1643, 2011.
- [46] Jo˜ao Magueijo et al. Cosmology with a spin. *Phys. Rev. D* 87, 063504, 2013.
- [47] Chechin L.M. Does the Cosmological Principle Exist in the Rotating Universe? *Gravitation and Cosmology*. 23(4): 305-310, 2017.
- [48] Longo M.J. Are Cosmic Isotropy Limits from Analyses of the Cosmic Microwave Background Credible? *Preprints* 2020, 2020110520
- [49] Shamir L. Asymmetry in Galaxy Spin Directions-Analysis of Data from DES and Comparison to Four Other Sky Surveys. *Universe*, 8, 397, 2022.
- [50] Nodland Borge and Ralston John P. Indication of Anisotropy in Electromagnetic Propagation over Cosmological Distances. *Phys. Rev. Lett.* 78(16), 3043-3046, 1997.
- [51] Pavan Kumar Aluri et al. Is the Observable Universe Consistent with the Cosmological Principle? *arXiv:2207.05765 [astro-ph.CO]* 2022
- [52] Seshavatharam U.V.S, Lakshminarayana S. Applications of Hubble Volume in Atomic Physics, Nuclear Physics, Particle Physics, Quantum Physics and Cosmic Physics. *J. Nucl. Phy. Mat. Sci. Rad. A.* 1(1), 45-60, 2013.
- [53] Seshavatharam U.V.S, Lakshminarayana S. Black hole Cosmos and the Micro Cosmos. *International Journal of Advanced Astronomy*. 1(2), 37-59, 2013.
- [54] Seshavatharam U.V.S, Lakshminarayana, S, Sai B.V.S.T. Is red shift an index of galactic 'atomic light emission' mechanism? *International Journal of Physics*, Vol. 1, No.3, 49-64, 2013.
- [55] Seshavatharam U.V.S and Lakshminarayana S. Cosmologically

- Strengthening Hydrogen Atom in Black Hole Universe. J. Nucl. Phy. Mat. Sci. Rad. A. Vol-3, No-2, 265–278, 2016.
- [56] U. V. S. Seshavatharam and S. Lakshminarayana. Is Planck's constant a cosmological variable? International Journal of Astronomy, 2(1): 11-15, 2013.
- [57] Seshavatharam, U.V.S., Lakshminarayana, S. Role of Four Gravitational Constants in Nuclear Structure. Mapana-Journal of Sciences.18,1,21, 2019.
- [58] Seshavatharam, U.V.S. Lakshminarayana, S. Implications and Applications of Electroweak Quantum Gravity. International Astronomy and Astrophysics Research Journal. 2(1),13-30, 2020.
- [59] Seshavatharam U.V.S and Lakshminarayana S. Is reduced Planck's constant - an outcome of electroweak gravity? Mapana Journal of Sciences. 19(1),1-13, 2020
- [60] Seshavatharam, U.V.S, Lakshminarayana S. 4G model of fitting RMS radius of proton. Nucleus 2022: Fundamental problems and applications. Moscow July 11–16, 2022. Book of abstracts, 88-89,2022. https://events.sinp.msu.ru/event/8/contributions/613/attachments/594/1212/ID_25_24_uvssa_sln_14July2022.pdf
- [61] P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2021) and 2021 update.
- [62] Hawking, S.W., Hertog, T. A smooth exit from eternal inflation?. J. High Energ. Phys. 2018, 147, 2018.
- [63] Alis J Deason et al. The edge of the Galaxy. Monthly Notices of the Royal Astronomical Society. 496(3), 3929–3942, 2020.
- [64] Pijushpani Bhattacharjee et. al. (2014) Rotation Curve of the Milky Way out to ~ 200 kpc. ApJ 785, 63. (13 pages)